Chapitre 3

# Stinking canals. The quality of surface water in Dutch cities, 1500-1970

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In terms of thinking, acting, feeling, and experiencing, managing the quality of surface water in the Netherlands has undergone important changes since the Middle Ages. Central to this study is the question of surface water quality or, put in a nutshell, when was surface water considered drinkable?

Concerns about the quality of surface water first emerged in cities, especially starting in the nineteenth century. By the early twentieth century the quality of surface water diminished even in the countryside, forcing the regional water authorities (*waterschappen*) and national government to become involved. The former were large and powerful institutions that had overseen the surface water in the countryside since the central Middle Ages, originally primarily aimed at drainage, and they still exist.

Environmental historians see the city as an organism with its own "metabolism[1]". The city "digests" inflowing matter, such as clean water, and discharges wastewater. The metabolic metaphor can also be applied on a larger scale, such as the region or country as a whole. Viewed as such, at least three interesting questions arise: When, how, and why did the wastewater flow originate in cities? How was the urban wastewater flow connected to the clean water flow in cities? And how was the water flow in cities connected to the surrounding countryside?

In this essay, we will focus mostly on the low-lying parts of the Netherlands, that is the coastal regions – a well-documented part of the country where the canal cities (*grachtensteden*) were located, and where significant problems with water quality management emerged at an early stage. Canal cities should be understood as cities situated in reclaimed wetlands where most transport was carried out over water, and where very few streets existed, or often only as small streets along canals or narrow passages between houses. Thanks to some recent, more extensive studies, comparisons can also be drawn with other parts of the Netherlands[2].

1 Schott, 2012, p. 15.

2 Van Dam, 2018A.

It is useful to divide the overall timeframe into separate periods. The first period, between 1200 and 1800, saw the emergence of cities and the laying of the foundations for managing dirty water (and waste) in a densely-built environment. After 1600 the surface water became polluted, partly due to large and rapid demographic growth. The next period, 1800-1914, saw innovations in thinking about the role of dirty (and clean) water, thanks to the hygienist movement. In addition, major political and economic changes took place that increased the political pressure and the financial means for installing sewer systems. The years up to the First World War are included in this period, on the grounds that significant economic growth took place from 1880 and continued until 1914. In the third period, between 1914 and 1970, wastewater technology advanced further. The water authorities and other parties developed a "water civilisation", leading to the first attempts at surface water quality management. The period ends in 1970 with the enactment of the Pollution of Surface Waters Act (*Wet Verontreiniging Oppervlaktewateren*), which made the regional water authorities responsible for managing surface water quality and cleaning all wastewater, and gave them the legal and financial instruments to achieve this. From that time onwards, cities entrusted the treatment of their dirty water to the regional water authorities[3].

## 1200-1800: From clean to fetid canals

Before addressing the history of the management of surface water quality, including flows of wastewater, let us briefly consider the role of surface water in the history of drinking water.

Research on medieval Amersfoort has shown that residents identified different levels of water quality and used them differently. Households had access to surface water and groundwater and decided how to use it and for what purpose. The best water, drinking water in a narrower sense, was used for consumption and for preparing food and washing clothes. Clean water of a lower quality, also known as domestic water by historians, was used for washing the body and watering cattle. Domestic water of even lower quality could be used to clean homes and other buildings, streets and vehicles, and to irrigate vegetable gardens. Industry also used water; bakeries and beer breweries needed drinking water, and bleacheries (companies that cleaned clothing and other textiles) and dyeworks needed high-quality domestic water[4].

3 The research for this article was done as part of of the research project 'Coping with drought. An environmental history of drinking water and climate adaptation in the Netherlands', N.W.O. nr. 406.18.HW.015, project website: www.copingwithdrought.com (accessed 15 november 2022). I thank the participants for comments on earlier versions of this text.

4 Alberts, 1917.

Throughout the Netherlands, surface water – particularly fast-flowing river water – initially must have been an excellent source of drinking water. Many a city was located by a river or even had a river flowing through it. In the sandy eastern and southern Netherlands, surface water was usually of sufficient quality to be fit for consumption. Urban households had their own wells, and there were also publicly accessible wells. Until c. 1600, in the canal cities of the peaty northern and western Netherlands, canal water could be used as domestic water and even as drinking water.

After 1600, people in some cities started to collect water from elsewhere, especially in cities in the coastal region where the canal water had salinised or become too dirty. In Alkmaar, Amsterdam and Leiden, brewers' watership regularly set sail to stock up on water for brewing beer. In Amsterdam, brewers and water enterprises collected water from the River Vecht, and in other cities they did the same from the coastal dunes. In the sixteenth century, people in various cities also started to collect rainwater, but further research is needed on the scale on which this happened[5]. These kinds of water, of higher quality, were expensive and thus only available to the elite. Higher-quality water was beyond the reach of the poor, and the latter remained dependent on surface water until the end of the nineteenth century, as we can read in reports of specialists[6].

From the moment cities emerged, city governments issued rules to protect surface water and built up an administrative apparatus for enforcement[7]. The provisions of the *Cuerbrief* (set of urban laws) of Aardenburg in 1250 against the contamination of waterways are perhaps the oldest in the Netherlands. Other similar provisions included bans on throwing waste and manure in the water and bans on discharging wastewater into the city canals. The supervision of the removal of waste was the responsibility of urban officials who oversaw important places in the city, such as the gatekeeper (Deventer), market superintendent and lockkeeper (Groningen). In the rest of the city, the citizens themselves had to keep their surroundings clean, something that was normally monitored by neighbourhood officials. Only the heart of the city was maintained by the government itself – that is, the area around central buildings such as the city hall, the weighing house, and important squares and thoroughfares. After 1600, the city government expanded its responsibilities, and the executive apparatus was extended further. In the late seventeenth century, Amsterdam had 200 street-sweepers, fixed containers for disposing of solid waste all over the city, and a fleet of dozens of garbage barges that collected the garbage from the containers twice a week; the latter, spread over 34 districts, crossed the city daily in accordance with a tight schedule. Solid waste was taken out of the city and sold to horticulturalists. In Deventer, there were landfill sites on the land outside

5 Van Roosbroeck, 2019.

6 'T Hart, 1997, p. 42.

7 Groningen, Leeuwarden Bolsward, Sneek, Hasselt, Oldenzaal, Kampen, Zwolle, Nijmegen, Amsterdam, Gouda, Haarlem, Aardenburg: Van Zon, 1986, p. 20-23.

the city gates, and, from 1450, anyone dumping waste in the IJssel had to ensure that this was done downstream of the city[8].

As urbanisation progressed, houses were built closer together and it became necessary to introduce regulations on house construction. This included the rise of the cesspit; in the west from 1350, in the east 100-200 years beforehand. In canal cities, the introduction of cesspits was explicitly intended to protect the quality of the canal water. Cesspits were metres-deep pits with wooden or brick walls for the storage of faecal matter and other materials often ended here too, like broken pottery, dead cats, other animals and animal parts. In the late Middle Ages, the emptying of cesspits was a job for specialists, who were known as "privy-cleaners" [*secreetruimers*] or "nightmen" [*nachtwerkers*]. Due to the stench, they only operated during the night. At the same time as the rise of the cesspit, bans emerged on the discharge of privy drains and other open and closed sewers that connected toilets and cesspits to the canals[9].

The use of cesspits and the existence of rules and monitoring to protect the quality of the canal water suggest that, in many places in the Middle Ages, the canal water was still suitable as domestic water and even as drinking water. Although it undoubtedly contained some (organic) waste, the water system still presumably had sufficient self-purification capacity to process it. After 1600, however, the canals in many cities became open sewers. By the seventeenth century, the smell of the canals in Amsterdam was so bad that the city was known as the "beautiful virgin with the bad breath". The city elite built lavish estates in the countryside, along the waterways and dunes, and in newly reclaimed areas such as drained lakes, in order to escape the stench, which was particularly unbearable in summer when the water level in the canals was low[10].

Why did the canals become public sewers after 1600? One cause was the end of the cesspit. Roos Van Oosten has revealed the political-economic power relations at play by comparing the cities of Leiden and Haarlem[11]. As the population was growing rapidly, Leiden's city government wanted to encourage project developers and homeowners to build a large number of houses at a fast rate, and therefore waived the obligation to construct cesspits from 1583. Instead, people were allowed to design "privy drains"' or open sewers, which discharged into the canals. The Leiden house lobby was highly resistant to cesspits, not only because they were

8 'T Hart, 1997, p. 42; Coomans, 2018, p. 79-86; Smit, 2001, p. 30-37; Bakker, 2004, p. 85; Abrahamse, 2019, p. 404.

9 Van Oosten, 2015, p. 104, p. 318: urban law of 1463.

10 Abrahamse, 2019, p. 395.

11 Van Oosten, 2015, p. 213-236; Van Oosten, 2016, p. 704-727.

expensive to build, but also because of the high costs of maintenance. There are indications that Amsterdam followed the Leiden model to promote industry[12].

Haarlem, by contrast, had a powerful export-led beer industry that had a great interest in clean surface water, both as raw material for beer and for rinsing the beer barrels. Here, the "murder of the cesspit", as Van Oosten puts it, was postponed for centuries. Only in the nineteenth century were cesspits replaced by privy drains in Haarlem, and this happened precisely after the brewing industry had collapsed.

In addition, in Alkmaar, Haarlem and Amsterdam, and probably in all canal cities, as a result of rapid population growth in the seventeenth century, the number of less well-off and poor citizens who used chamber pots, buckets and other mobile night-soil containers increased. These containers were illegally emptied into the canals by those who had no access to sewers and could not afford to make use of the mobile alternative, the nightmen's boats[13]. In short, fewer and fewer households were using cesspits, and many houses were discharging faecal matter directly into the canals.

Industry also polluted the urban surface water. There were policies regulating the industrial discharge of wastewater, including spatial directives demanding concentration in certain areas or rejection to the periphery. At the end of the sixteenth century the city of Leiden concentrated the most polluting branches of the woollen and leather industries in the area called Maredorp, situated along a canal that carried (polluted) water out of the town. Yet other industries were banned totally, like the glueproducers who had to settle at a distance of at least three kilometers outside the city walls. A big issue was the tension between water quality, the need to keep and attract industries, and lack of space. Maintaining rules concerning already existing industries was thus often lenient, which meant that industries could often stay where they were even when it concerned the very polluting dyeing and bleaching industries (Leiden 1600). The rules were strictly enforced for newly-founded industries. In periods of rapid demographic growth, like in the first half of the seventeenth century, industries were allowed to settle in new city extensions, thus outside the center, yet where many labourers lived. Examples are the dyers in the Verversbuurt in Leiden and the blue-dyers and the producers of chamois-leather in the Jordaan in Amsterdam. The chamois-leather producers, who used train-oil from whales among other ingredients, were even allowed to dig a ditch behind their buildings for discharging liquids, which over time received the name of Stinking Ditch (*Stinksloot*) and was connected to one

12 Abrahamse, 2019, p. 379, p. 405.

13 Alkmaar, Haarlem, Amsterdam: Van Oosten, 2015, p. 115, p. 202.

of the main city canals[14]. In some cases special measures were issued. In 1582, Haarlem's linen bleachers were told that they had to settle their wastewater, which was contaminated with bleach and starch, in separate settling tanks. Yet other businesses emerged, like Haarlem's cotton printers, vermillion manufacturers, white-lead works and saltpeter refineries that discharged polluting corrosive and acidic substances. Allowing industrial discharge not only had a negative impact on the quality of the surface water, but the policy of tolerance also undermined the legitimacy and credibility of the city government when it monitored the same regulations for households[15].

The gradual increase of buried sewers following the disappearance of the old cesspits led to new regulations. Various cities made attempts to reduce the impact of the buried sewers on the main (navigation) canals system. Single sewer pipes had to be fitted with a grate at the mouth of the canal, a measure dating back to medieval times, but that only kept out coarse dirt[16]. Several cities had collection sewers, but only for Leiden, built in the seventeenth century, they have been investigated. Originally, they were canals. Because they gave off too much stench, they were overarched so that they looked like a huge, long cellar of hundreds of meters. Successively the private sewers of all the buildings were connected to it, including the drains from the roofs. The collection sewers remained only partially connected to the other canals, for only the liquid was supposed to drain off. The remaining solid waste was cleaned out by the same branch of entreprises that had cleaned the older cesspits[17]. The material was taken outside the city to special places (*stalen*), where it was stored for re-use (fertilizer). The sludge dredged from the city canals was also moved there.

In addition to the significant rise in the discharge of faecal matter and industrial wastewater, there were two spatial factors that led to a reduction in the circulation of surface water, which, in turn led to further deterioration in water quality, particularly in the low-lying peatlands in the north and west. The first was the changing height difference between the city and the surrounding area. Since the start of the reclamations around the year 1000, the ground level in the peatlands had sunk by around a metre per century (due to oxidation and settlement). In the sixteenth century, cities such as Delft, Leiden, and Amsterdam, which were located in the middle of peatlands, started to rise above the landscape like little islands.

14 Smit, 2001, p. 67-69 ; Abrahamse, 2019, p. 95, p. 401. On the topic of regulating industrial pollution, no systematic studies exist. It may well be that another issue prevailed in the new expansions of the 17th century, including the need to incorporate already existing economic activities that were situated outside the former city wall, an issue problematized by Abrahamse.

15 Huisman and Buiter, 2007, p. 390; Smit, 2001, p. 67; Abrahamse, 2019, p. 399.

16 Rules for Utrecht in 1427 in Van Der Monde, 1844, 128-30, with thanks to Marja Heier; for The Hague in 1637, see Foncke, 2020, p. 58.

17 Smit, 2001, p. 63, p. 74.

They were less and less able to use the relief that had originally caused a natural flow in their canals. The second spatial factor that contributed to the deterioration of surface water quality was the expansion of the canal system. The longer the total length of the canals, the greater the resistance to flow in the canals and the slower the water flowed. This was particularly disastrous in Amsterdam, where only the small River Amstel flowed into the city, and where many kilometres of canals were added in the seventeenth century[18].

In order to combat the noxious stench, cities sought ways to accelerate the refreshing of the canal water. The cities constructed systems of weirs and locks, which allowed the water to be stored for some time in certain canal sections. An artificial fall was created, temporarily creating a faster flow. Ideally, the dirty water was discharged from the city at night, when shipping traffic was at a standstill. Some cities accelerated circulation by making creative use of wind energy or tidal energy. Windmills were installed at the drainage locks on the edge of the city, to pump the wastewater out and the clean water in. This usually had insufficient impact, due to under-capacity. Cities located close to the mouths of great rivers where a tidal regime prevailed, such as Gouda, let water in at high tide and water out at low tide. This process, known as *schuren*, also involved salt water, but that meant that the canal water became salinised and was of limited use as domestic water[19].

In their attempts to refresh the city waters more rapidly and effectively, cities had to deal with the regional water authorities that managed the water flow in the countryside. It was useful to be able to cut off a city's water system from the surrounding countryside; this allowed the city to raise its water level more easily and also prevented dirty water from flowing to rural areas. Amsterdam's Amstel locks were built for this purpose in 1673, with the consent of two neighbouring authorities, the regional water authorities of Amstelland and Rijnland. Unfortunately, the measure did not have the desired effect, because the city government was unable to raise the water level sufficiently. In fact, there was a much better way for Amsterdam to refresh its waters effectively. In theory, water from the lake known as the Great Haarlem Lake (*Grote Haarlemmermeer*) could be routed through the city. In doing so, use could be made of the impoundment of water due to wind, which could cause the level to rise by metres in some places. However, initiatives to this end were repeatedly blocked by the Rijnland regional water authority, which managed the level of the Great Haarlem Lake. Rotterdam's attempts to close off the city failed altogether. For centuries, there had been friction between the city and the Schieland regional water authority about the level of the small rivers that flowed

18 De Bont, 2001; Van Dam, 2008, p. 95-99; Abrahamse, 2019, p. 416.

19 Van Tielhof and Van Dam, 2006, p. 158-164; De Bont, 2001; Abrahamse, 2019, p. 422-444; Van Dam, 2018B, p. 19; Sloof, 1988, p. 25.

through the city, the Rotte and the Schie – a problem that would only be solved in the nineteenth century[20].

In summary, in the Middle Ages, little wastewater and solid waste was discharged into the surface water, and presumably the water was of high quality. After 1600, cities had to contend with rapid population growth and the expansion of industry. Urban canals became open sewers because households discharged their faecal matter *en masse* and industry added new, highly polluting substances. Water circulation also deteriorated due to geographic changes and urban expansion, especially in canal cities located in peatlands.

## 1800-1914: Towards the hygienic city

In the late nineteenth century, the introduction of the integrated flush sewer system was the solution that was eventually chosen to promote the quality of surface water in cities. This system consisted of a water closet (WC) connected to an underground sewer system, in which wastewater was propelled by pumps. This system did not really get off the ground until 1890, however. The Hague achieved it in 1893, and Amsterdam in 1907-1913 but only in the suburbs, whilst the city centre had to wait until the 1930s. Many other European cities made the transition earlier: Hamburg in 1843, London in 1865, Paris in 1871, Berlijn in 1873 and even faster in America (Brooklyn in 1855 and Chicago in 1856)[21]. Why did the Netherlands only adopt this system after 1890? According to the existing literature, a true "hygiene transition" was required, something that came about through the "hygienist" movement, and that could only be translated into action in a favourable political-economic climate. The hygienists were a group of doctors, chemists, engineers, entrepreneurs, citizens, and politicians who devoted themselves to promoting healthier urban living conditions[22].

In the second half of the eighteenth century, the first scientific views were advanced on the relationship between health and the role of surface water. Matthias van Geuns, a medical doctor from Groningen, was the first to present a coherent set of public health measures in 1773, which were published in Dutch in 1801. In his view, residents' health was an important element of the prosperity of the citizenry. The government thus had to ensure good doctors and proper nutrition, and pay attention to soil hygiene, air purity, waste removal and the drainage of fetid water. These ideas harked back to the miasma theories that were formulated long ago in classical antiquity and that had dominated medicine ever since (although they had

20 Abrahamse, 2019, p. 408-421; Van Der Ham (ed.), 2004, p. 69-178; Van Noort, 2000, p. 13-17; Foncke, 2020, p. 59.

21 Geels, 2006, p. 1072.

22 In this paragraph and the following I devote only little attention to industrial water pollution because available research is limited.

not or hardly been substantiated with empirical research). Bad air played a central role according to these theories: it caused people to fall ill. Polluted water was also an important element because it led to bad water and thus to disease. A simple solution was to build sewers, something Van Geuns proposed[23].

The theories about the relationship between dirty surface water and health first had to be proved with empirical research before they could be disseminated and accepted. Young Dutch doctors played a role in this process. The 1832 outbreak of cholera was an unexpected spur to action. Cholera was a highly contagious new disease that spread like wildfire, and classical medicine could offer no answers. The young doctors took inspiration from abroad: France, Germany and England were home to progressive physicians who viewed themselves as "advocates for the poor". They saw it as their task to provide an accurate account of social wrongs. To this end, they introduced a scientific and statistical approach, which led to a new public health doctrine and new concern about public health. The health of the population was expressed in figures relating to age, sex, birth, mortality, disease, body weight and diet. New methods for evaluating environmental characteristics, including chemical methods for measuring water quality, were also being improved all the time[24].

As a result of political turmoil and the new Constitution of 1848, doctors were part of the new (male) groups of citizens who gained the right to vote and thus had more opportunities to manifest themselves politically and administratively. They took the initiative to set up local health committees that, like those abroad, issued scientifically substantiated reports about urban hygiene. Doctors also gained more clout at the national level, thanks to the founding of the *Geneeskundig Genootschap* (Medical Society) in 1865 and the appointment of local medical inspectors following the Medical and Health Acts of 1865[25].

In due time, the physicians' programme would receive support from chemists, engineers, entrepreneurs, citizens, and politicians, who supported the so-called hygienist movement. It would nevertheless be many years before the movement had a real impact on urban hygiene policy. For decades, no consensus existed on two points. First, the causes of poor public health, in particular epidemic diseases such as cholera. Competing theories had emerged alongside the miasma theory. Were these infectious diseases that were transmitted from person to person? This view implied quarantine measures, the isolation of the sick and the disinfection of homes. Or was it about bad air, as the older theory claimed? In that case, it was important to purify the soil, water, and air. The second point on which the hygienists disagreed was about how to dispose of faecal matter: with or without a sewer system and, if so, which type?

23 Van Zon, 1986, p. 23-32.

24 Lintsen, 2005, p. 58-60; Van Zon, 2003, p. 35.

25 Lintsen *et al.* (ed.), 2018, p. 60-162.

Table 1. Rejected designs for sewer connections

Source: Geels, 2006, 1077.

| Year | City |
|---|---|
| 1858 | Rotterdam |
| 1863 | Arnhem |
| 1870 | Amsterdam |
| 1870 | Tilburg |
| 1872 | Den Haag |
| 1872 | Arnhem |
| 1876, 1878 | Den Haag |
| 1897 | Amsterdam |
| 1902 | Amsterdam |

The choice of drainage system was of great importance in this regard because the pollution of urban surface water was largely due to the discharge of human excrement. Over time, cities considered and rejected many variants on sewers (**see table 1**). In principle, the variants were based on three technical ways to dispose of faecal matter: the barrel system, the Liernur system and the flush system. The flush system with the WC became the dominant system, and in the twentieth century it eventually gave rise to enormous investments in wastewater treatment plants and the formation of a national policy on surface water quality. It is therefore fascinating to consider why the competing options – the barrels and the Liernur system – failed to take root. Both were dry urban manure systems, which yielded a relatively dry substance with a high concentration of fertilizers. As such, it could potentially be sold to farmers, preventing its release into the surface water[26].

With the barrel system, households were fitted with excrement barrels (*poeptonnen*). These were collected several times a week, and the contents were processed into compost and sold as manure. The system was thus essentially a continuation of the time-honoured system of cesspits and mobile containers for urban manure. However, the big difference was that the barrel system was run centrally by a company or city service, which delivered and collected the barrels. After Groningen launched a barrel system, sales of urban manure proved economically advantageous. For that reason, other cities also became interested. In Leeuwarden, the number of barrels rose from 300 to 2 500 between 1873 and 1879. In Dordrecht, the number of barrels also rose significantly, from 314 in 1874 to 2 759 in 1883. Cities that followed their example included Amsterdam, Rotterdam, Leiden, Vlaardingen, Arnhem, Nijmegen, and Maastricht.

26 Geels, 2006, p. 1076; Lintsen *et al.* (ed.), 2018, p. 61-63.

The Liernur system, developed by engineer Liernur, consisted of dry toilets connected to pipelines that ended in a reservoir. The excrement was extracted daily to the reservoir by a pump that operated on steam power, making use of the vacuum principle. It appears to have been similar to the modern aircraft toilet. Breda, Leiden and Amsterdam were among the few cities to experiment with this system from 1867. The Liernur system had the same advantage as the barrel system – the production of relatively dry urban manure – but it was technically complex and expensive, not least because the quality of the compost was disappointing. People disposed of too much dishwater and suchlike in the toilet[27].

Dry urban mature systems could only succeed if urban manure was financially attractive for farmers; in other words, if the production and transport costs were low, for example because the distance between the city and the farmer was short, or because there was a good connection over water. There also had to be sufficient demand from farmers. Those who farmed on fertile clay soils or farmers who had a lot of cattle needed less manure than farmers with sandy and peaty soils or those who specialised in arable farming and horticulture. The price of urban manure therefore differed per city and per region, and this is probably the main reason why cities opted for different solutions at first. In the Province of Groningen, the price was high because there was great demand for manure. In the reclaimed peatlands of the provinces of Drenthe and Groningen, the removal of the peat had left a need for significant amounts of manure in order to process the leftover sandy soil into fertile agricultural land for potato cultivation, among other things. In the cities of Veendam and Assen, the urban manure was auctioned and sold to the highest bidder[28].

Until 1890, cities mainly opted for the cheapest solution, the barrel system. Aside from the wavering attitude of the hygienists, the liberal political climate played a key role in this. Cities wanted to limit their costs, so that taxes could be kept as low as possible. After the reforms of 1848, municipal policy was controlled by a liberal lobby of retailers, lawyers, industrialists, property specialists and other businessmen who had an interest in low taxation. In addition to such cultural and

27 Van Zon, 1986.

28 Van Zon, 1986, p. 207-209. In earlier centuries urban manure, combined with building debris and other waste, was often used for leveling and raising grounds. Jaysena, 2020, p. 253. Yet some indications exist that from c. 1500 onwards, farmers used urban manure under specific conditions like good drainage of the fields, see Knibbe, 2006, p. 88 (Friesland), and in horticulture in nearby towns, see Smit, 2001, p. 38 (Leiden 1459) and Abrahamse, 2019, p. 404 (Amsterdam, 1666). In the late 18th century, along with an increase of systematic knowledge about fertilizers, the trade in urban manure expanded. From Amsterdam, Leiden, The Hague, Delft, Rotterdam, and Dordrecht urban manure was exported to Flanders and Brabant as fertilizer for specialized agriculture, Abrahamse, 2019, p. 404; Van Driel, 2016, p. 71; De Graef, 2017. In the 19th century the Dutch regions of Zeeuws-Vlaanderen and Goeree-Overflakkee as new centers for the production of sugar beets used much urban manure, Lintsen *et al.* (ed.), 2018, p. 478, note 9.

political factors, the strong economic upswing from c. 1880 was also important, because the city collected more tax revenue as a result. Another point was that from the mid-nineteenth century, the construction of drinking-water systems absorbed much of the political attention and financial resources[29].

After 1890, a shift occurred and the flush system came into favour. The hygienist movement's civilising offensive was fuelled by new and respected knowledge about harmful microbes, thanks to foreign scientists such as Robert Koch and Louis Pasteur. In the past, people had mainly considered it annoying that the stinking barrels had to be installed in homes, and that the transport of barrels was accompanied by spills and stench. In the late nineteenth century, by contrast, dirt and dirty water were no longer seen as annoying, but as a direct threat to public health.

Another important factor was that, in the late nineteenth century, a link was drawn between the hygienists' ideas and the so-called social question. This was related to the new groups who gained a voice in the municipalities. Suffrage was gradually extended from the wealthy to more people, including the masses of workers who lived in slums and who, inspired by the international socialist movement, stood up for their rights. The government was held responsible for the living conditions of all citizens, not just those of the upper classes. Hygiene, together with poverty, public housing, and the labor issue, became part of the social question, which focused on improving workers' lives.

In addition to increasing knowledge about hygiene and the political-economic transformation in the late nineteenth century, the introduction of the flush system with the WC was also promoted by the new bathing culture that developed during the nineteenth century[30]. Whereas public bathhouses were still common in the Middle Ages, they disappeared in subsequent centuries due to a complex host of religious and other factors. Few physicians recommended the cleansing of the body with water anymore. Based on theories that were just as ancient as the miasma theories, there was a prevailing fear of cold water and "raw" water (fresh, unboiled water). Under the influence of new health theories, however, especially from Central Europe, (cold) water came to be perceived as healthy again. By the nineteenth century a spate of true water therapies had arisen, including cold showers, for which waterfalls probably served as a model. Jacob van Lennep, a celebrated author from Amsterdam's upper middle classes, regularly visited spa centres in Germany with his family to relax and recuperate. In the Netherlands, bathing in the sea and river water also became popular among the elite. In Maastricht, a floating bathhouse was set up on the Meuse River (1828). The new bathing culture manifested itself in the late nineteenth century with the rise of beach recreation, the establishment of public bathhouses and swimming pools, and the installation of private bathrooms

29 Geels, 2006, p. 1074-1077.

30 Geels, 2005; Lintsen, 2005, p. 69-70.

in (wealthy) households. Water was transformed from being a source of danger to being a source of relaxation. Moreover, thanks to the new public knowledge about disease-causing microbes, cleanliness was no longer a matter of beauty and decency, but an essential condition for public health[31].

In this context, in parallel to the discussion about the discharge of dirty water, a debate arose about the construction of drinking water systems. From the mid-nineteenth century, drinking water systems were built and operated by drinking water companies. The construction of drinking water pipes advanced the building of sewers because the barrels in the barrel system overflowed as soon as a tap was installed in a house. The connection of toilets to the drinking water mains was highly appreciated in the context of the new bathing culture; the time-honoured stench could be washed away with large quantities of clean water, giving rise to a modern, clean feeling[32].

The breakthrough of the flush sewer system in cities resulted in a great improvement in hygiene – in the home, at least. But where did the wastewater go? For a long time, sewage was still being discharged inside or outside the city into the surface water. This was partly related to the discovery of the "self-purification capacity of water", which, according to Henk van Zon, would take on a life of its own and determine policy well into the twentieth century[33]. The consequences were evident from the complaints in the area of the Uitwaterende Sluizen regional water authority regarding the discharge of Amsterdam's canal water into the North Sea Canal. In 1886, it was stated: "The canal water is a major disadvantage to landholders, whose cattle have to drink that fetid water, especially noticeable during cheese-making! Could Amsterdam not shift the refreshing of the city's canal water in another direction, towards the Zuiderzee[34]".

31 Mathijse, 2018, p. 45, p. 342, p. 348 and my ongoing research; Lintsen, 2005, p. 63-64.

32 Lintsen, 2005, p. 63-64; Geels, 2005; Bakker, 1997, p. 87-116.

33 Van Zon, 2005, p. 34.

34 Schilstra, 1969, p. 177.

Table 2. Introduction of drinking water systems

Source: Bakker, 1997, 92; Giebels, 2002, 142.

| Year | City |
|---|---|
| 1853 | Amsterdam |
| 1856 | Den Helder |
| 1874 | Den Haag, Rotterdam |
| 1878 | Leiden, Katwijk |
| 1879 | Nijmegen |
| 1881 | Groningen |
| 1882 | Dordrecht |
| 1883 | Utrecht, De Bilt, Delfshaven, Gouda |
| 1884 | Vlissingen |
| 1885 | Arnhem, Baarn, Soest, Alkmaar, Vlaardingen |
| 1886 | Schiedam, Gorinchem, Hilversum, Zaanstreek |
| 1887 | Maastricht, Den Bosch, Sliedrecht, Roosendaal |
| 1888 | Leeuwarden, Kampen, Oud-Beijerland, Nieuwer-Amstel, Delft |
| 1889 | Venlo, Zutphen |
| 1890 | Tiel |
| 1891 | Maassluis |
| 1892 | Middelburg, Enschede, Almelo |
| 1893 | Zwolle, Deventer |
| 1894 | Breda, Apeldoorn, Meppel, Delden |
| 1895 | Tilburg |
| 1896 | Hellevoetssluis, Harderwijk, Zeist |
| 1897 | Hengelo, Assen |
| 1898 | Haarlem, Nijkerk, Rheden, Zwijndrecht |
| 1899 | Bergen op Zoom, Helmond, Roermon |

The late nineteenth century saw an increasing need in cities to intensify the refreshing of canal water. Cities were often dependent on water authorities for this, but cooperation now appears to have progressed more smoothly than in the seventeenth century. The cholera epidemic of 1866 may have initially prompted the cities of Zuid-Holland to ask the water authority to help refresh the cities' canals. Water from the Meuse was subsequently let into the regional water authority of Delfland, and it was also carried through to the regional water authority of Rijnland. In the last quarter of the century, cities in Rijnland appealed to the water regional water authority to drain the waterways more often. The regional water

authority charged the cities a fixed rate of 50 guilders for additional drainage, for the extra coal and labour used[35].

Regarding the pollution of surface water by industry for the nineteenth and twentieth century, almost no scholarly literature exists for the Netherlands, in contrast to France where Geneviève Massard-Guilbaud has contributed substantially to the scholarship on the topic[36]. The absence of such research is partly due to the fact that the Netherlands industrialised at a later date (only after 1850) and that the main sources of the nation's wealth have always been trade, rather than production; as such, economic historians focused on trade. The history of industrial pollution has been studied primarily as an aspect of the history of technology[37]. From an environmental history perspective a few pioneering case-studies on industrial pollution exist, but they focus on water pollution by industry situated in the countryside (potato-flour and dairy production)[38]. For the nineteenth century, the legislative framework for pollution control has been researched by historians of industry (in particular the history of the chemical industry).

During the French occupation (1795-1813), the first national rules for controling pollution were issued. The Imperial Decree of 1810 focused on restricting conditions for the settling of industry. After the foundation of the national state of the Netherlands in 1813, the Royal Decree of 1824 revised the conditions. Less emphasis was placed on industry zoning and more on complaints of inhabitants against licenses. One may see this as a shift from the more centralistic French model to a model that is closer to the English one[39]. The reality is that, before the French period, the Netherlands were a Republic with very autonomous cities, so this might also have been a return to a more Dutch style of government: decentralised, inconsequent, incoherent, and based more on negotiations than on centrally determined rules. Monitoring of industry was weak because enforcement powers were lacking, in particular committees of experts were not specified in the Royal Decree (in contrast to the situation in France).

In 1874, the Nuisance Law was passed. Historians argue that the country's late industrialization meant that it had not been needed earlier. While the Nuisance Law gave municipalities the power to issue licences for new industries and monitor their activities, it was not effective at limiting industrial pollution due to flawed methods

35 Giebels, 2002, p. 136, p. 142.

36 Massard-Guilbaud, 2010.

37 Lintsen, 1992-1995; De la Bruheze, 1998-2003.

38 Oosthoek, 2002; Plantinga, 2022, chap. 5.

39 Le Roux, 2016, p. 80.

of pollution monitoring and the lack of enforcement. In fact, cities sided with the companies when citizens raised complaints[40].

## 1915-1970: A "WATER CIVILISATION"

After the First World War, the hygienists' civilising offensive took the form of a new "water civilisation" that resulted in new policy. With the Housing Acts of 1901, it became compulsory for homes to have a flush toilet and this was soon followed by the dissemination and increasingly intensive use of the shower. From 1960, many public bathhouses were shut down, and water use increased rapidly; for example, private water use in Tilburg quadrupled between 1940 and 1970. The cleaner body was accompanied by cleaner clothing, which had to be washed more often. By 1972, 85 % of Dutch households had a washing machine, and this also contributed to rising water use per capita. That fact that the associated bathing culture and personal hygiene also flourished is also apparent from the increasingly luxurious and more personal design of bathrooms. In 1938, all towns with more than 50 000 residents had an integrated flush system, although many still had cesspits and barrels, too. This was due ro the rapid expansion of new residential neighbourhoods; indeed, it was relatively easy to construct sewers before the houses were built, as opposed to laying sewer canals in existing neighbourhoods. The number of wastewater treatment plants also increased steadily, from a few dozen in 1945 to 275 by 1965[41].

In the twentieth century, the cleanliness of surface water in cities was no longer the sole concern. For instance, after the First World War, some factories started demanding clean surface water for their industrial processes (transporting, cleaning, cooling), adding their voice to the swelling choir calling for clean surface water.

A major problem for the water authorities was that no proper legislation existed that could prevent the pollution of surface water. A bill in 1903 misfired while a bill in 1919 never made it to the House of Representatives. The consideration of a subsequent bill was postponed time and again by the same House. A new preliminary bill was drafted in 1955, but it took until 1970 to bring it into law[42]. Nevertheless some progress was made in the intervening period, and it rested on the efforts of a small group of specialists to persuade and convince polluters. The staff of the National Institute for the Purification of Wastewater (*Rijksinstituut voor Zuivering van Afvalwater*, RIZA, part of the Ministry for Agriculture), founded in 1920, played a key role in this, as did officials from the regional water authorities, which took care of the surface water in the countryside, various departments at ministries, provinces and several large municipalities, and engineering firms. At the same time, new degree programmes were founded at the universities of Delft and Wageningen, such as Civil Health Engineering and Wastewater Treatment

40 Homburg, 1994; Diederiks and Jeurgens, 1989, p. 205-206.

41 Lintsen, 2005, p. 70-72

42 Giebels, 2002, p. 142, p. 258.

and Water Quality, which supplied the necessary specialists[43]. The specialists were also inspired by environmental interest groups such as the Dutch Association against Water, Soil and Air Pollution (*Nederlandsche Vereeniging tegen Water- Bodem- en Luchtverontreiniging*), which began a study on water quality in 1936, and, from 1960 onwards, by the nascent environmental movement[44].

The Delfland regional water authority in the Province of Holland was one of the first to set requirements for discharge into surface water. Due to the highly polluting industry in the city of Delft, it had attached conditions to the granting of permits for the discharge of factory water since 1917. From 1930, the Rijnland regional water authority attached conditions to discharge from municipalities. While the size of the levy for municipal discharge permits depended on the number of inhabitants, municipalities could negotiate a lower levy if they managed to prove that they took central sewerage and the active purification of wastewater seriously. This policy on the part of water authorities was not or hardly supported by legislation. Rather, this was part and parcel of what Ludy Giebels has called a "water civilisation". This was the water authorities' version, as it were, of the nineteenth-century hygienist movement. The "water civilisation" is evident, for example, in a letter from Rijnland engineer Paul de Gruyter to his technical officials: "Pure surface water is of great value to public health (bathing, swimming, washing vegetables), to shipping, water sports, fishing, to industry and above all to the moral standard of living of the entire community. The unsightly appearance and disgusting stench of heavily polluted water runs counter to any sense of civilisation. The demands made by the community in relation to the general improvement of the quality of people's lives have increased enormously in recent decades[45]".

Through an amendment to the Nuisance Act in 1952, it became possible to set requirements for wastewater discharge by companies – and this was sorely needed. All kinds of highly polluting industries had arisen in the meantime, not only in the city, but also in the countryside. Canning factories occasionally released spoiled, salty vegetables into the water; vegetable washing and drying plants regularly discharged wastewater. Various kinds of new synthetic materials had also emerged, which were discharged without any significant purification. Eventually, in 1950, the Dommel water authority in the Province of Brabant was the first water authority to start wastewater treatment. It was given the power to impose charges for discharge, and thereby the ability to finance wastewater treatment plants. A dozen water authorities took up quality assurance in similar ways, and the system was eventually enshrined in the Pollution of Surface Waters Act of 1970[46]. This act gave the regional water authorities responsibility for

43 Jansen, 1995, p. 20.

44 Van Zon, 1986, p. 240; Giebels, 2002, p. 142, p. 257.

45 Giebels, 2002, p. 260.

46 These were the water boards with starting years: De Dommel 1950, De Donge 1950, De Aa 1956, Geleen en Molenbeek 1957, De Geul 1957, De Berkel 1962, De Regge 1962, Uitwaterende Sluizen 1965, Hunsingo 1969, see IJff, 1995, p. 27; Jansen, 1995, p. 21-24; Lintsen, 2005, p. 71-72; Schilstra, 1969, p. 182.

surface-water quality management in the countryside, as well as the legal and financial instruments to achieve it. From that time onwards, cities entrusted the treatment of their dirty water (which would otherwise end up in the surface water of the countryside) to the water authorities. A new phase in surface-water management had begun, one that continues to this day.

## Conclusion

What does this overview of 800-year history of the management of surface water in the Netherlands tell us about flows of matter (and water), urban metabolism, and recycling? Firstly, after 1600, the quality of surface water in the cities declined sharply and city canals became stinking open sewers, particularly in the low-lying west. Under pressure from strong demographic growth, houses discharged faecal matter and industries had *carte blanche* to discharge waste. Moreover, it became increasingly difficult to refresh the canal water in the western peatlands, because the water flow in the cities declined.

A comparison with France may be revealing here, guided by the classic study by André Guillerme, *The Age of Water*. I read this as a student and it was one of the great books that inspired my work in environmental history; as it was for Geneviève with whom I collaborated intensively to build up the European Society for Environmental History[47]. During the Ancien Régime, northern French cities struggled with stagnating water because they enclosed themselves behind walls and wide moats in order to cope with frequent wars. In Holland, the stagnation of city waters was not related to war; the origin of the problem was actually the sinking of the countryside (due to reclamation of peatbogs), while the built city stood on piles and became an isle. Another factor was the extension of canals in the cities, which increased resistance and slowed down the water flow.

Secondly, the flow of dirty surface water, loaded with faecal matter and industrial wastewater, emerged in the 16th century when the wastewater flow was redirected from cesspits and settling tanks to sewers and canals. In the late 19th century, the introduction of dry manure systems signified a new, but almost immediately missed opportunity to keep faecal matter out of surface water. With the integrated flush system, a more or less circular economy for the re-use of urban manure from households was broken for good; a cycle that had functioned for centuries (c. 1200-1600), but that had been eroded by the abolition of cesspits and the spread of "privy drains" from 1600. It is an intriguing thought that if the history of surface water had developed differently, we would not have wastewater treatment plants operated by the regional water authorities, but an urban-manure processing industry.

47 Guillerme, 1998, p. 137-138.