Accepting Father Rhine? Technological Fixes, Vigilance, and Transnational Lobbies as 'European' Strategies of Dutch Municipal Water Supplies 1900–1975.

CORNELIS DISCO

University of Twente
Dept. of Science, Technology and Health Policy Studies
School of Business, Public Administration and Technology
P.O. Box 217, 7500 AE, Enschede, The Netherlands
Email: c.disco@utwente.nl

ABSTRACT

Downstream users of river water (e.g. municipal waterworks) always face the problem of controlling the behaviour of upstream polluters. In the case of an international river like the Rhine this is exacerbated when there are no international arrangements constraining upstream polluters. This demands flexibility and creativity from downstream waterworks. In this article I describe the repertoires developed by the municipal waterworks of two large Dutch cities, Amsterdam and Rotterdam. Two main repertoires are visible: 1) 'coping' by means of technical fixes and vigilance and 2) 'transnational technopolitics' aimed at institutionalising regulatory regimes to curb pollution. Rotterdam, totally dependent on Rhine water, emphasised 'coping' on a day to day basis, placing its trust on technologies of purification and vigilance. Amsterdam, using dune and lake water though envisioning future use of Rhine water, pursued a long-term strategy aimed at improving the purity of the Rhine's waters – including extensive longitudinal pollution measurements and transnational technopolitics. During the 1950s, the Amsterdam waterworks played a major role in forging international links among waterworks along the Rhine culminating in a sectoral organisation of Rhine Waterworks. This was one of the foundation stones on which the riparian nations were gradually able to build an effective regime for pollution control.

KEYWORDS

Water supply, Rhine, pollution, water treatment, international governance

Environment and History **13** (2007): 381–411. doi: 10.3197/096734007X243140

'The Netherlands are the lowest lying region on the Rhine and we simply have to accept what Father Rhine gives us.' [1]

INTRODUCTION

Surface water, i.e. water from lakes and rivers, has long been used as a source of potable water. With the advent of modernity, the purity of these waters was increasingly compromised by the waste effluents produced by growing cities and manufacturing processes. Throughout the nineteenth and most of the twentieth centuries the 'search for the ultimate sink', as Joel Tarr has aptly called it, often ended in the nearest convenient lake or river.[2] Surface water was generally seen as an unrestricted public good in which one could dump wastes at will; those subsequently desiring to consume the tainted water bore the burden of rendering it safe to drink. Prevailing opinion held that dilution, mixing and the presumed 'self cleaning' capability of especially flowing water was sufficient to ultimately neutralise pollutants – even if certain stretches of rivers or portions of lakes had to be 'sacrificed' to progress. The pervasiveness of this point of departure is well documented for at least the United States and it also seems to have been the general consensus in Europe.[3]

But this one-sided view of the matter could not be maintained indefinitely. Toward the end of the nineteenth century a combination of factors, including increased levels and varieties of pollution, increasing demand from growing cities for clean water in response to repeated cholera and typhus epidemics, progress in microbiological theory and in biological and chemical assay techniques, improvements in the technologies of drinking water purifcation and sewage treatment, and the wave of 'urban progressivism' sweeping the western world, made it more likely that surface-water polluters, under certain conditions, would be called to account. This happened, for example, in the wake of a plan to construct a central sewer system in the rapidly growing Rhine city of Mannheim in the 1880s.[4] The question of where to dump the collected effluent naturally arose. In 1896, Mannheim's proposal to flush the lightly treated sewage into the Rhine was reviewed by a committee of medical and engineering experts appointed by Baden's Ministry of the Interior. The committee considered the effluents to be tolerable, especially in view of the masses of water conveyed by the Rhine, which would dilute and then break down the raw sewage. 'Trusting in the power of habit and the imperceptibility of pollution, the experts assumed that Rhine residents downstream of Mannheim would quietly put up with faecal pollution in the river as long as they were not reminded of it by obvious, easily perceived signs.' [5] However, the experts did not count on the tenacity of the municipality of Worms, situated 12 km downstream of Mannheim's sewer outlet. The inhabitants of Worms depended on the Rhine for drinking water, albeit after filtration through layers of gravel and sand, and they did not want to run the risk of infectious diseases from Mannheim's sewage. Despite the fact that Mannheim's 1898 concession called for a costly sewage treatment plant and regular monitoring of water quality in the Rhine, Worms continued to object. This led Baden's Ministry of the Interior to convene a second commission which took a much more stringent view of the effects of Mannheim's effluents, especially in view of the bad precedent which would be provided by the proposed lax sewage treatment measures. As the committee argued:

> This same right allowed to Mannheim could not be refused the rest of the cities on the Rhine or its major tributaries, and the effluents from these cities with their then 2–3 million inhabitants would pollute the Rhine in an obviously disgusting way. Such possibilities have to be countered in time in order to avoid conditions as they have frequently developed elsewhere, for example, in England.[6]

The commission recommended that Mannheim be compelled to upgrade its sewage treatment practices – though with allowances made for the huge volume of water of the Rhine. However, it also called on Worms to reform its drinking water purification practices in accord with the latest bacteriological insights.[7] It was clear that the consumption of surface water and its pollution – at least between near neighbours – was potentially becoming an intricate *pas de deux* with both partners under pressure to perform according to the dictates of modern science and technology.

This *belle epoque* idyll might have flourished and led to more effective regulation of pollution on the Rhine and elsewhere had history taken another course; i.e. had not twentieth-century militarism, industrialism and consumerism and the associated burgeoning of steel, chemical, cereal and arms industries established other priorities on the river. As it was, the deleterious effects of the effluents of large municipal sewer systems, which basically aggravated the organic pollution of the river, gradually began to pale in comparison with the effects of industrial pollution, a process well documented by Mark Cioc.[8] Public health officials and sanitary engineers made great strides in understanding organic pollution and its effects and in developing effective countermeasures – both in terms of sewage treatment and water purification. Industrial pollutants, however, were another kettle of fish. The problem was not simply the brute increase in industrial toxins. It was rather the large number of small and discrete sources, the often mysterious nature of the compounds and their unknown effects on crops, animals and humans, ignorance about their breakdown and half-lives in river water, and finally the sometimes catastrophic nature of industrial pollution associated with spills, fires and other accidents. All these factors made it difficult for water-using plaintiffs to make a case against polluters – even when they could be identified.

These problems were only exacerbated when the surface water in question took the form of rivers, particularly rivers like the Rhine that passed through and between different political entities. This was already a problem in the case of

Mannheim and Worms which, though only 12 km apart, were located in different German states and were hence not subject to the same courts or to common governance arrangements – at least not with respect to pollution control. Hence, while the commission appointed by Baden's Ministry of the Interior could make forceful recommendations about sewage treatment in Mannheim, it could do little but offer good advice to the waterworks managers in Worms.

In this article I want to focus on the twentieth century and examine the much greater challenge faced by consumers of river water located a hundred or more kilometers downstream of sources of pollution and in a different country. I will examine how the municipal waterworks of the Dutch cities of Amsterdam and of Rotterdam attempted to maintain the purity of their drinking water by managing their relationships to Rhine water and to upstream polluters, i.e. German, French and Swiss cities and industries. Because these consumers and polluters were separated by national borders, by hundreds of kilometres of river, and by the time it took catastrophically polluted swatches of river water to travel from the source of pollution to the downstream waterworks intakes, interactions were mediated by different levels of government, the flows of the river and warning systems. This mediated action-at-a-distance meant that strategies to ensure water quality at the point of consumption could be of different kinds: 'technological fixes' based on utilising different methods of water purification and intake regimes, 'vigilance' based on early warning of waves or periods of pollution followed by closure of the intakes and reliance on buffers, or 'transnational organisation' based on motivating governments to (get other governments to) regulate the behaviour of polluters.

There is a certain hierarchy in these options: from the local to the cosmopolitan and parallel to this, from the technological to the political. The first option embodied the classical notion that it was the responsibility of municipal waterworks to either seek out pure sources of raw water or to employ purification technologies to remove harmful pollutants from tainted sources (like the Rhine). This was a local and by and large a technological solution, although the rhetorical struggle about what was to count as 'clean' or 'healthful' water inevitably introduced a political and cultural element. The second option depended on the creation of national (and ideally transnational) systems of real-time monitoring of water quality. Besides local investments in freshwater buffers, it involved national and international standardisation of measurement practices and a fiduciary relationship with upstream riparian governments and their monitoring agencies. The third option involved complex chains of national and transnational political lobbying and negotiation, aimed in the first instance at mobilising national governments to fight surface water pollution with the aim of achieving bilateral agreements on curbing Rhine pollution, but having ultimately also a European dimension in the form of transnational water-quality commissions.

The main actors in this account are the Municipal Waterworks of the cities of Amsterdam and Rotterdam (see Figure 1). Amsterdam's waterworks became

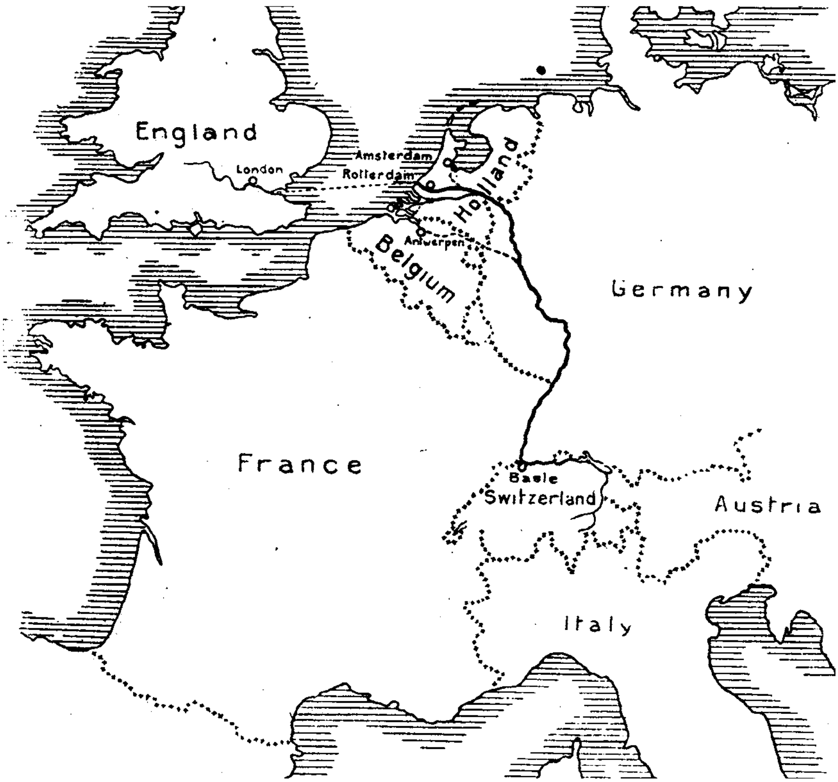

FIGURE 1. The Rhine as northwestern Europe's transnational river. Rotterdam (on the river) and Amsterdam (60 km away from a branch) are visible near the river's mouth. The heavy black line is the river. Dotted lines are national borders. Tributaries like the Mainz, the Neckar and the Moselle are not shown in this map. (Source Gelpke, 1919: 2.)

municipally owned in 1896. During the next sixty years, and despite an unabating stream of plans and projects to draw water from the Rhine, qualms about the Rhine's purity caused the waterworks management to persist in seeking its drinking water closer to home – a strategy that according to all prognoses could not be maintained forever. Indeed, in the 1950s demand became so great that a Rhine pipeline could no longer be put off; by 1958 it was in operation and Amsterdam had become a consumer of Rhine water. Meanwhile, Rotterdammers had been drinking processed Rhine water with relative impunity since the inauguration of their municipal waterworks in 1874, trusting to 'natural' purification technologies supplemented with chemical treatment. The municipal waterworks of both cities maintained a fairly constant vigil over the quality of Rhine water, Rotterdam as a corollary of day-to-day survival, Amsterdam in anticipation of its (perennially postponed) plans to utilise Rhine water. These assays and observations of the patterns of Rhine pollution in fact produced an historical record of the river's deterioration going back to 1898. In the 1930s Amsterdam's waterworks took the lead in fostering programmes of collective vigilance among Dutch Rhine waterworks. After the Second World War, the Dutch Rhine Waterworks Commission, again spearheaded by the Amsterdam Waterworks, lobbied to get pollution control on the international Rhine agenda. This led directly to the founding, in 1950, of the International Committee for the Protection of the Rhine against Pollution (ICPR) and, from the early 1970s, to a transnationally coordinated campaign to restore the river as a source of clean water. Hence, it was only after the Second World War that the prevailing culture of free pollution began to be seriously challenged at an international level, and, practically speaking, only until well into the 1970s that these efforts began to bear fruit.[9] The question is why and how this shift in strategies took place: how 'plaintiff' downstream cities were finally able to get Rhine pollution on the international agenda – and why they initially had recourse to other, less political, options.

AMSTERDAM: PURITY

On 14 June 1853, an Amsterdam newspaper reported that on the previous day a large number of 'curious and interested' citizens had congregated to witness a 'strange spectacle' outside the Willemspoort, namely 'to see pure and good drinking water spout out of a fountain'.[10] The water had been collected in a network of drainage canals in the coastal dunes west of the town of Haarlem, fed into a reservoir and subsequently pumped a distance of 25 km through pipes to the Willemspoort fountain. This private initiative, financed by British capital and carried out by British engineers, marked the advent of piped drinking water in Amsterdam – and indeed in the Netherlands as a whole. In subsequent decades the dune water system gradually replaced existing sources of potable water like rain barrels, wells and the transport of water by barge from outlying lakes.

But the rapid population growth that set in after 1870, along with increased per capita demand due to the slow but steady development of a new hygienic 'water culture', soon overtaxed the revolutionary dune water system.[11] During hot summers the company was unable to maintain pressure and faucets on upper floors ran dry. In 1885 the Dune Water Company was granted a concession by the city to extract water from the river Vecht, east of Amsterdam.[12] However this river was burdened by sewage from the city of Utrecht and the Amsterdam Public Health Commission forbade its use as drinking water, even after filtration. It was thus delivered through a separate pipe system as utility water for cleaning, industrial use, and fire-fighting. Vecht water, though plentiful, was thus not a solution for the scarcity of *potable* water.

The chronic potable water shortage and the consequent frictions between the city council and the Board of Directors of the Dune Water Company impelled the city to buy out the company in 1896. Soon after, a search for new sources of potable water led to the digging of trial wells in the downs east of the town of Hilversum. In addition, a covetous eye began to be cast on the Rhine, a branch

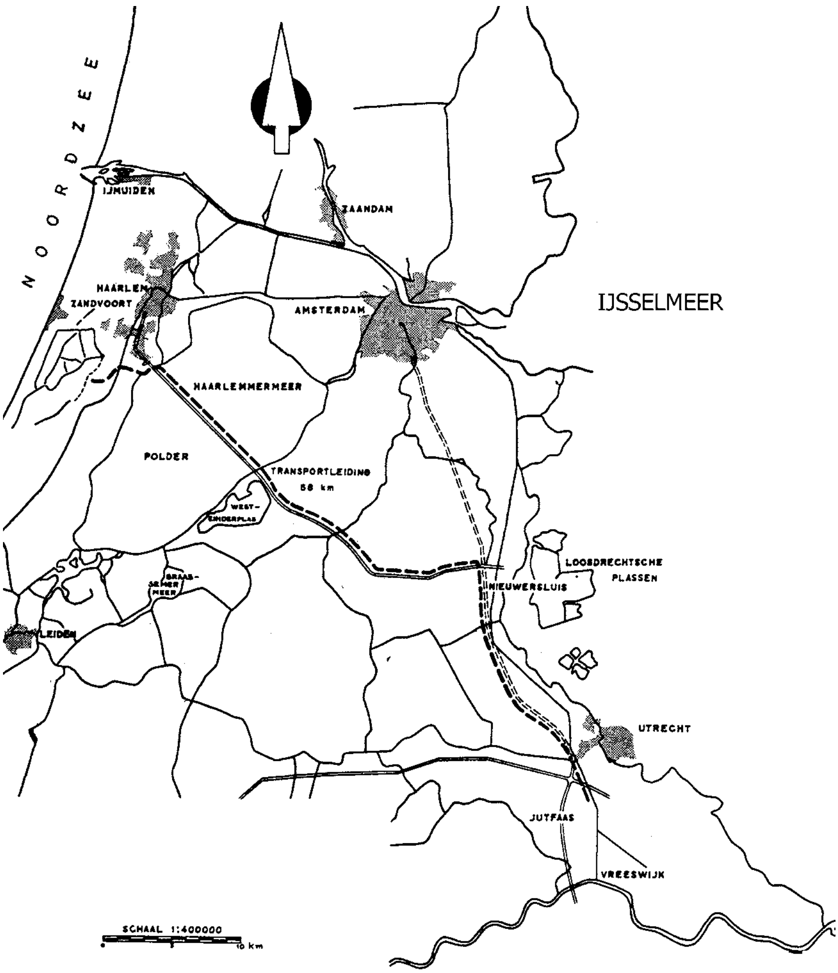

FIGURE 2. Amsterdam's raw water sources. Amsterdam is at the upper centre. The dune catchment is due west close to the North Sea. The lake catchment is southeast of Amsterdam, about halfway to Utrecht. The Lek is at the bottom-right. The heavy dotted line marks a possible route in the1948 proposal for a pipeline from the Amsterdam-Rhine canal to the dune catchment. (Source Biemond, 1948: 46.)

of which (the Lek) passed Amsterdam at a distance of only 60 km. In order to assess the biological and chemical suitability of Rhine water, Amsterdam's Municipal Waterworks set up a laboratory on the *Nederrijn* in 1898 in which daily samples of riverwater were analysed.[13] In January, 1901, three options were proposed by the new waterworks director: extracting groundwater from the Hilversum downs, piping Rhine (Lek) water directly into the city (after sand-bed filtration) or, finally, 'infiltrating' Lek water first into the dune water system (see Figure 2). In the latter option, filtration through the dunes would do the preliminary work of purification after which a final round of slow sandbed filtration, aeration and storage could produce potable water.

But the city council baulked at the high cost of these ambitious projects and opted for a cheaper proposal involving deep-well extraction of groundwater in the dunes. This 'emergency' measure alleviated the immediate shortage so that recourse to the Rhine seemed less urgent. Although by 1916 the city board had in principle decided in favour of the dune infiltration option, high wartime prices for construction materials forced postponement. To combat the pressing water shortage, measures were instituted to avoid wastage and conserve water. In a subsequent report published in December, 1924, no fewer than seven possibilities for new water sources were identified, including the Rhine, but also wells in the high sand grounds of the Veluwe, some 70 km away. A new series of investigations into the quality of Rhine water included efforts to identify specific sources of pollution in the Ruhr area according to the nature of the pollutants and correlating changing pollution levels with upstream events like labour strikes and holidays.[14]

ROTTERDAM: PURIFICATION

'While the location of the waterworks-intake on the tidal Maas, within reach of unwanted effluents and the sometimes excessive salinity of floodwaters, might well have occasioned a search for a new waterworks inlet, the more so as the water has for many years suffered from episodes of bad smell and taste, the waterworks stuck to its original location.'[15] Thus did R.P. van Royen, former head of the Amsterdam waterworks, express both astonishment and admiration for Rotterdam's tenacity in consuming the Rhine water which flowed at its doorstep.

Indeed, while Amsterdam's Municipal Waterworks had gone no further than dipping an exploratory toe into the Rhine, Rotterdammers had been blithely drinking Rhine water both prior to and since the inauguration of their own municipal waterworks in 1874.[16] This despite the fact that from the outset Rotterdam's Municipal Health Commission had advocated a dune water system like Amsterdam's, citing the proximity of upstream cities and indeed of Rotterdam's own sewage outlets to the proposed water intake. This aversion to procuring drinking water from rivers appeared to be the consensus among public health officials, at least if we credit a newspaper summary made of a report submitted by Delft's Public Health Commission to the Delft City Council in 1912. The reporter paraphrases: 'As a general principle, in our country the extraction of water from the large rivers for public water supplies is to be avoided. The cause is the pollution of the rivers within and without our borders. However, where recourse to the rivers cannot be avoided, then the greatest possible guarantees must exist that at all times the water meets fair standards of hygiene.'[17] Apparently Rotterdam's Public Health Commission was prepared to bow to the necessity of using river water, but as a 'fair' guarantee of hygiene they demanded (expensive) chemical purification of the river water.[18] A committee of civil and sanitary engineers appointed by the Rotterdam city council disagreed. The engineers were of the opinion that even without chemical purification the Maas could deliver 'good and usable drinking water for everyone'.[19] The engineers carried the day and state-of-the-art waterworks purification practice was adopted: precipitation in short-term storage basins followed by 'biological' slow sand-bed filtration. Part of the Health Commission's worries had been due to the tidal nature of the Maas at Rotterdam, which meant that with every tide the direction of the river's current changed and that hence there was no location that was always upstream of the city and its sewage outlet. However, thanks to the river's own flow, the situation was not symmetrical and some advantage could be gained by placing the water intake in the classical location, i.e. formally upstream of the city in the direction of the river's source. Nonetheless, in order to prevent the city's own sewage from entering the waterworks inlet when the current flowed in the 'wrong' direction, i.e. from the sewage outlet to the water intake, the intake sluice had to be opened for only a brief period as the tide went out and the current was decidedly seaward. Rotterdam's waterworks system thus supplied itself by means of huge and precisely timed 'gulps' every twelve hours. These 'gulps' were stored in large precipitation basins and further processed according to demand (see Figure 3).

Several episodes of waterborne typhus and other infections kept the idea of chemical purification alive in Rotterdam. However, the perceived risks outweighed the fears of bacterial infection and Rotterdam stuck to its sand filters – which multiplied along with demand. In the cold winter of 1911, with the Rhine unusually low, Rotterdammers experienced the first of a long series of episodes of a 'phenol' taste to their drinking water. This was just a couple of years after the first 'phenol tasting' Rhine salmon had been reported.[20] While the bad taste in Rotterdam went away again, suspicions did not. The Rhine became less and less trustworthy, particularly at low discharges when there was less water to dilute the pollutants. No one knew for certain what caused the bad taste and who or what was responsible – although the accusing finger inevitably pointed to large chemical firms in the Ruhr.

FIGURE 3. Rotterdam's waterworks in 1923. The water intake fitted with Stoney sluices is at the right foreground. There are two large storage and sedimentation basins. To the rear of the complex the slow sand filters are visible. The pumphouse and water tower are at the left. (Source KLM Aerocarto.)

Meanwhile, demand in Rotterdam increased as the post-World War One depression gave way to renewed prosperity. In view of the limited space at the waterworks site, it was deemed impossible to increase the number of slow sand filters, and so recourse was had to two new sand and gravel 'fast filters'. Though sufficiently compact, biochemical analysis showed that the two filters alone provided inadequate purification. A second stage was deemed necessary. This could be accomplished either by accelerated filtration through the existing 'slow' beds or by chemical purification in the form of chlorination.[21] As before, the Municipal Waterworks shied away from chemicals and opted for accelerated filtration through the slow sand filters. However, additional 'phenol taste' episodes during the cold winter of 1929 finally overcame resistance to chemicals and by 1931, when the new fast sand filters actually came on line, chlorination was adopted as well.

THE TASTE AND SMELL OF RIVER WATER

In 1916, in response to the 1911 episode of 'phenol' taste, the Government Bureau for Waterworks was asked by the National Public Health Board to carry out a series of chemical and bacteriological assays of water in the Lek River, a branch of the Rhine that ultimately flowed past Rotterdam.[22] On the basis of standard tests for dissolved salts and organic matter, the bureau concluded that the water was eminently suited for the production of potable water. These results confirmed the daily assays taken by Rotterdam's Waterworks. Nonetheless, continuing reports of ill-tasting, diseased and dead fish, plus the common knowledge that stretches of the German Rhine had been deliberately 'sacrificed' to the waste-disposal needs of industries and cities, sustained suspicions among the waterworks community and environmental activists about the quality of Rhine water in The Netherlands.[23] In 1917 this prompted the Government Institute for Hydrographic Fisheries Research (*Rijksinstituut voor Hydrografisch Visserijonderzoek)* to investigate possible causes of fish disease and starvation, with as primary suspect polluted river water.[24] The previous year's investigations by the National Bureau for Waterworks seemed to gainsay this suspicion, but the anomaly was resolved when the attention of the fisheries researchers was drawn to a greyish substance that sometimes clung to the bottoms of salmon nets and which fishermen described as rotted paper.[25] Earlier investigators, including the Government Bureau for Waterworks had not included the deep water near the river bottom in their analyses. Now it became evident that the water near the bottom of the river occasionally transported not only the greyish substance, but also 'all kinds of refuse, like potato peels, vegetables, shreds of paper and leaves'.[26] Upon analysis, the greyish substance turned out to be shreds of a species of fungus and it seemed reasonable to suppose that this might have something to do with lowering the resistance of salmon and other fish to disease. The question now was whether these fungi were of native origin or had been swept downriver from Germany – and if so whence.[27] The riddle was partly solved when it was discovered that, as the investigator reported, 'these fungi as it were carried their birth certificate along with them in the form of fragments of German newspapers on which the gothic print was still very clearly readable'.[28] Efforts to cultivate the fungus revealed a great affinity for carbohydrates and this pointed the finger at a number of large cellulose factories operating along the German Rhine in connection with the wartime production of gunpowder and explosives. German literature on river pollution had in fact noted the prevalence of fungi near the wastewater outlets of these cellulose factories, which, given the exigencies of war, were not overly fastidious about releasing effluents.[29] The Dutch fisheries investigator reasoned that during periods of high water and swift currents these fungi were torn from the riverbed and swept downstream. Once the system had been 'flushed out' and the river restored to a normal condition, the waterborne shreds of fungi temporarily disappeared. Hence their prevalence in spring when thawing snow and ice augmented the Rhine's flow. The investigator also saw a link with the occasional 'phenol' taste of the river water and salmon, although he was uncertain about the precise causal relationship. The conclusion was that in the warmer seasons the 'self-cleansing' capacity of the Rhine could be counted on to combat the 'deleterious influence of polluted German Rhine water'. However, in the 'spring flood the polluted water is transported so rapidly that there is too little time for adequate self-cleansing, and thus German water conditions are, as it were, transported hither'.[30]

By undertaking these investigations the Dutch government was tacitly defining Rhine pollution as a *national* problem and an *international issue*, transcending specific sectors like waterworks and fisheries or particular urban waterworks, and locating the source of the trouble unambiguously in the upstream portions of the Rhine, particularly in heavily industrialised regions of Germany like the Ruhr. This momentum was of short duration, however. With the cessation of hostilities after the First World War and the subsequent collapse of the German economy, foul-tasting water and fish starvation abated, temporarily suppressing downstream concerns. However, by the beginning of the 1920s increased demand for clean drinking water and German economic resurgence once again put Rhine pollution on the agenda.

The inhabitants of Rotterdam, no less than their waterworks engineers, had little choice but to ride out the Rhine's recurrent waves of pollution as best they could, relying on their own vigilance and inventiveness. In the course of time, both a rudimentary theory of Rhine pollution as well as a repertoire of official and semi-official countermeasures were developed. Observing that episodes of bad taste and smell inevitably occurred in the winter when both the river and the temperatures were low, the *Nieuwe Rotterdamsche Courant*, Rotterdam's major newspaper, presented the following explanation and *apologia* for an episode of bad taste and smell at the close of 1921: 'German industry flushes organic compounds into the Rhine which in the summer, not counting the workings of living organisms, are oxidised. When the river is low, as it has recently been, much less water is transported and the concentration of these compounds is higher. Moreover oxidation, which is retarded when the temperature is lower, especially after a freezing spell, proceeds too slowly. The result is the unpleasant taste, against which no other measures can be taken than those already incessantly and meticulously applied by the municipal waterworks.'[31] As usual, the Municipal Waterworks had hastened to assure the populace that though the water indeed tasted and smelled poorly, extensive tests had shown that there was no reason for concern about bacteriological infections or epidemics. However, this failed to assuage a certain K.H. de Haas, a concerned reader who responded to the paper's conclusion that German *industrial* and hence largely *non-organic* pollution was at the root of the bad taste. In his letter to the editor, Haas stated that 'it would now undeniably be of the greatest interest to hear that chemical analyses too were unable to reveal any harmful substances'.[32] Haas then revealed his own home-grown strategy for dealing with evil-tasting mains-water: 'By pouring mains water into soup plates and exposing it thus to the air for 24 hours, I have observed that the bad smell and taste are nearly completely eliminated.'[33] Haas saw no reason why the municipal waterworks could not employ a similar strategy on a larger scale.[34]

Starting in 1927 a number of developments served to couple the local concerns of Dutch waterworks and their customers with a concerted national effort to chart Rhine pollution and to try to influence these flows at an international level. The process was galvanised by a letter from the director of Hamburg's Municipal Waterworks to the Dutch National Bureau for Waterworks describing episodes of bad-tasting water on the Elbe and asking whether similar conditions prevailed on the Rhine. Perhaps seeing a diplomatic opening toward Germany, the Dutch Ministry of the Interior and of Agriculture responded by establishing a broad-based interdepartmental 'Commission for Taste and Smell of River Water' to investigate conditions on the Rhine.[35] Earlier, as noted, Amsterdam had started a Rhine water analysis program at Rhenen (see Figure 4). The Taste and Smell Commission provided an important forum for the diffusion of the Amsterdam findings throughout the Dutch water and public health community. In the unusually cold winter of 1929, with the Rhine at low ebb and covered with ice, a new and prolonged episode of 'ground' and 'phenol' taste sorely tried the patience of water consumers in Rotterdam and other nearby riverine waterworks.[36]

These episodes of bad taste prompted the Commission on Taste and Smell to undertake its own series of extended measurements of water quality on the main branch of the Dutch Rhine, the Waal, starting in March, 1931.[37] On the basis of these measurements, the commission concluded that Rhine pollution was decidedly increasing. However, it was no more able than Amsterdam's chief chemist at Amerongen, J.A. Heymann, to provide a satisfactory biochemical explanation for the 'phenol' taste. As Heymann had demonstrated, bad taste and smell appeared to correlate poorly with other indicators of organic and inorganic pollution. However, these indicators appeared alarming enough to the commission researchers for them to refuse to actually taste unprocessed Rhine water as part of their analysis protocol.

Another long-standing threat to the quality of Rhine water, the salt or chloride content, also became more prominent in this period and became a core concern of the Taste and Smell Commission. Excessive salinity, unlike extreme organic or bacteriological pollution, could not and cannot be combated in a cost-effective fashion and can, therefore, render a body of water useless as a raw water source. Up to 1931, though the increase in salinity had been alarming enough, it did not yet *on average* exceed even Amsterdam's stringent norm of 100 mg of chloride per litre.[38] Until that time the main causes of chloride pollution had been effluents from the Westphalian coal mines which entered the Rhine via the Emscher as well as various municipal sewer systems along the Rhine itself.[39]

OVERZICHT maxima, gemiddelden en minima van den Rijn gedurende de jaren 1927—1931.

Bepalingen, enz.	Maxi-mum	Gemid-delde	Mini-mum
Stand in m + N. A. P. . . .	9,86	5,91	3,95
Temperatuur in ° C.	23,2	11,2	0
Kleur, na filtratie door asbest .	33	14	5
Geleidingsvermogen	850	441	240
Vaste stoffen	605	332	203
Zwevende stof	327	35	2
Gloeiverlies daarvan	37	8	1
„ in %	64	25	11
$KMnO_4$ verbruik	43,2	20,5	10,3
Chloorgetal	30,6	15,7	9,5
Chloor	161	61,9	19,5
Nitraat	6,4	3,2	1
Nitriet	0,450	0,125	0,032
Zwavelzuur	77,7	45,1	24,9
Hydrocarbonaat	221	162	93
Vrij koolzuur	18	5,2	2,7
Agressief koolzuur	5,3	0,3	— 3,3
Kiezelzuur	25,2	8,0	0,4
Ammonium	2,15	0,32	0
Alb. ammonium	0,58	0,16	0
IJzer	2,45	0,36	< 0,02
Mangaan	0,18	0,02	0
Calcium	98,1	63,9	43,6
Magnesium	14,3	9,9	2,6
Alcalimetalen, berekend als Na^+	88,5	29,3	8,0
Vrije zuurstof	12,6	8,7	4,9
Verzadigingspercentage . . .	99	78	43
Biochemisch zuurstofverbruik na 24 uren	1,8	0,8	0
Biochemisch zuurstofverbruik na 2 × 24 uren	3,5	1,4	0,5
Assimileerbare organische stof .	83	60	34
Chloorbindend vermogen . . .	0,7	0,4	0,1
Kalium	6,3	2,9	0,4
Totale hardheid	17,0	11,3	8,2
Carbonaathardheid	10,1	7,4	4,3
Jodium	20	7	0
Verhouding $Cl' : SO_4''$		1,4	
„ Vaste stoffen : Geleid. verm.		0,74	
„ Chloor : geleid. verm.		0,15	
„ „ : Na^+ . . .		2,2	

FIGURE 4. Chemical and biological composition of Rhine water as measured in the Nederrijn at Rhenen in the years 1927–1931. Shown are the maximum, average, and minimum values for a large number of different impurities and physical properties of the daily water samples. The units depend on the parameter. For the different chemical substances concentrations are expressed in milligrams per liter. (Source Heijmann, 1932: 229.)

But in 1931 it transpired that the French government was about to grant its Alsatian potash mines a concession to dump their waste salts – which until then had been stored in huge mounds near the mines which were gradually leaching into the subsoil – into the Rhine. Although the concession stipulated precisely how much salt could be dumped per day, an amount indexed to the momentary discharge volume of the Rhine, the Dutch waterworks community considered any increase in Rhine salt levels as a 'stab in the back'.[40] Under the aegis of the Commission on Taste and Smell of River Water, the matter could be framed as a national problem (as opposed to a problem for a specific municipal or regional waterworks) which could be pursued through diplomatic channels. However, the formal complaints of the Dutch ambassador in Paris fell on deaf ears. As a last resort, in March, 1933 the Commission on Taste and Smell delegated two of its members, W.F.J.M. Krul, the director of the Government Bureau for Waterworks and R. van Royen, director of the Amsterdam Waterworks, to Paris and Alsace to speak informally with French representatives and engineers and to assess for themselves the gravity of the situation. Krul and van Royen were forced to the conclusion that the Dutch waterworks community had overreacted. Due to technical limitations in processing the waste salts, cutbacks in potassium production because of the onset of what would eventually become known as the Great Depression and increased international competition, much less salt would be dumped than had originally been foreseen and the level of salinity at Lobith (where the Rhine enters the Netherlands) would therefore increase by only 20mg/litre – serious but far from deadly.[41]

A further impetus for the nationalisation of the drinking water question in this period derived from the activities of the so-called Commission for Waterworks in the Western Region of the Country (*Commissie Drinkwatervoorziening Westen des Lands)* appointed in 1931 under the aegis of the Central Commission for Waterworks. This heavily urbanised and industrialised 'western region', including Amsterdam and Rotterdam, was threatened with saline intrusions from the sea and hung in the balance between its traditional dependence on the pure but finite dune water resources and a future in which suspect but plentiful Rhine water loomed large. Rotterdam had skipped the 'dune water phase' and in this respect was already in the vanguard, fighting Rhine pollution for better or worse with its up-to-date purification technology. Amsterdam, as we have seen, remained undecided: loath to forsake its inexpensive and pure dune water supply but increasingly compelled to cast its fate on the turbid waters of the Rhine. Throughout the 1930s the Commission systematically investigated alternative new sources of drinking water, including the newly reclaimed IJsselmeer and the Rhine.[42] In its report, submitted in 1940, the commission concluded that these latter two sources, whatever the risks, were the only feasible options for the waterworks in the west.

As the mission of Krul and Van Royen to France (and other Dutch initiatives in the Ruhr) demonstrated, the nationally organised Dutch waterworks were deeply interested in exploring possibilities for regulation of upstream pollution. The French response to complaints about salt dumping was not at all encouraging and German polluters were hardly more cooperative. The Great Depression had surprisingly little effect on levels of pollution because despite cutbacks in industrial production there were also fewer investments in pollution control. Incidental works, such as the aforementioned sewage treatment plant in the mouth of the Emscher, brought some relief, but after 1936, when the Rhine's industrial capacity became enrolled into Hitler's war machine, the condition of its waters deteriorated again. In the 1930s it was hard to get leverage on Germany in any case. To begin with, there were the priorities of the Nazi regime, which tended to privilege war production above pollution control. But there was also the fact that, as Amsterdam's Waterworks Director R. van Royen put it: '… on the way from Basel to our border one cannot find a single waterworks that uses river water as its raw material'[43] In Van Royen's opinion, the fact that German cities themselves had abandoned direct extraction of raw water from the Rhine, made them unwilling partners to negotiations and hence explained the absence of national measures or an international treaty against Rhine pollution. [44] Van Royen noted that existing international regulations for the Rhine had extended only to navigation and, in a later phase, to fisheries. 'The unfortunate people, among which the 700,000 inhabitants of Rotterdam and Dordrecht, have not yet gained as much attention as the fish. One can find no regulations in which the interests of public water supply are mentioned'.[45]

In response to the episodes of foul-tasting water in 1929 as well as the uncooperative attitude of upstream polluters, both Rotterdam and Amsterdam proceeded to transform their waterworks into fortresses against a suspect and above all unpredictable Rhine. For Amsterdam this meant developing alternative supplies of raw water not directly fed by the Rhine; for Rotterdam, upgraded purification technologies and much larger storage buffers appeared to be the only way forward in the long term. Amsterdam succeeded once again in avoiding dependence on Rhine water by developing a new intake for its old non-potable Vecht River Waterworks in the Loosdrecht Lakes west of Hilversum (see fig. 2).[46] These were fed by Vecht water and by groundwater seepage from a large aquifer under the Hilversum Downs. Purification depended on the natural self-cleaning activity of the lake, followed by slow sand filtration and light chlorination. Rotterdam, after implementing its two-stage sand and gravel filtration process in 1931, repeatedly had to increase the level of chlorination as a precaution against bacterial infection and finally had to adopt expensive and slow 'active carbon' filtration to deal with the increasingly frequent periods when the river water tasted badly. An additional strategy under consideration was the construction of large storage basins outside the city. These could save water withdrawn from the river when pollution levels were low for processing and consumption during episodes of high pollution, for example during frosts when river discharge was minimal and concentrations of pollutants highest.

THE INTERNATIONAL ARENA: COMING TO GRIPS WITH POLLUTION ON THE RHINE – AFTER A FASHION.

During the Second World War, the *Rijkswaterstaat,* the Dutch National Hydraulic and Public Works Agency, developed the concept of the 'national water household'. Its *Leitmotif* was the equitable distribution of fresh Rhine and Meuse water throughout the country, both to supply waterworks and irrigation facilities as well as to push back the encroaching saline intrusions in the various estuaries and tidal rivers. First, the freshwater needs of industry, shipping, agriculture, waterworks, and water-level management would be inventoried. Subsequently existing canals and rivers would be modified (by building weirs and locks) in order to manage flows of water within the country.[47] The waterworks sector figured prominently in the design of this freshwater system because it was a very critical consumer in regard to water quality in general and to the quality of Rhine water in particular. These requirements had been clearly delineated in two major reports published in 1940.[48] In its new self-appointed role as national freshwater manager, the *Rijkswaterstaat* became the major arena for formulating Dutch freshwater requirements in regard to the quantity and quality of Rhine water and the chief actor responsible for representing these requirements in international fora. Moreover, in 1945 the *Rijkswaterstaat's* expertise in the domain of pollution control was considerably bolstered by the incorporation of the Government Institute for the Purification of Wastewater (RIZA).[49] By 1947 the *Rijkswaterstaat* had instituted its own regular program of measurements of Rhine water quality at several sites along the Dutch Rhine branches.

Meanwhile the ongoing monitoring of the Rhine by Amsterdam's Municipal Waterworks and the Dutch riverine waterworks showed by 1946 that, after a significant dip in the last two years of the war, levels of chemical pollution in the Rhine were again rising at a spectacular rate as the postwar German and French economies began to revive. It was clear that if nothing were done, the Rhine would soon be dirtier and saltier than ever before. This was especially trying for Amsterdam's waterworks, which was again looking to the Rhine in order to alleviate presumptive future shortages. In bulky reports submitted in 1940 and again in 1948, Amsterdam's Waterworks Director, the civil engineer C. Biemond, concluded that the best option for Amsterdam's future water supply was infiltrating Rhine water into the porous sands of the city's existing dune waterworks catchment. However, though the report was not explicit on this sensitive point, it was essential that indicators of Rhine pollution, particularly inorganic pollution – including salts – remained below certain specified values. This entailed a huge risk. The value of major investments in new waterworks facilities and indeed the fate of much of the Netherlands' future water supply would now be at the mercy of the wastewater legislation of the upstream riparian powers.

Utilising the excellent relationship with the *Rijkswaterstaat* that had been cultivated prior to and during the war, Amsterdam's Municipal Waterworks took the lead in pressuring the Dutch government to get the issue of Rhine pollution onto the agenda of the Central Commission for the Navigation of the Rhine – in effect using a long-established diplomatic network to piggyback the issue of pollution onto the international agenda. In mid-April, 1946, the case was put before the Commission with the outcome that the delegates agreed to impress the gravity of the situation on their respective governments.[50] A subsequent Dutch memorandum to the Swiss government stressed the dangers which Rhine pollution presented to both the Dutch water household as well as to Rhine fisheries. The memorandum argued that it would be advantageous for all the riparian states along the Rhine to enter into negotiations in order to improve 'the quality of Rhine water on the basis of an agreement'. The aim would be to establish 'which demands are necessary in order to ensure a desirable degree of purity of the water and which purification measures should be taken'.[51] The Swiss government, itself worried about ailing salmon fisheries and increasing pollution in the Rhine-fed Swiss lakes, and particularly in the Bodensee, which was also burdened by effluents from its German shore, seized the occasion of an international limnological congress in Switzerland in 1948 to initiate a serious debate on Rhine pollution. At the First International Conference on Salmon Fisheries on the Rhine held at Basel later that same year, the delegates resolved that an international commission should be established to tackle the problem of wastewater effluents on the Rhine.[52] Thanks especially to diplomatic efforts by the Swiss government, the 'International Commission for the Protection of the Rhine against Pollution' (ICPR) was established in the spring of 1948 with Switzerland, Germany, France, Luxemburg and the Netherlands as charter members.

Though it wasn't until 11 July 1950 that the new commission actually met, again at Basel, time had not been wasted. In short order and by unanimous consent it had been agreed to set up a technical sub-committee charged with investigating patterns of pollution on the river. The proposed 'physical and chemical measurements' were intended to determine 'the present condition of Rhine water along its entire course and subsequently to get this acknowledged by all the states bordering the Rhine, as a basis on which the purification of the Rhine should be grounded'.[53] In a retrospective account, the first chairman of the ICPR, the eminent Swiss botanist and ecologist Otto Jaag, noted that the subcommittee's first order of business was to establish standard, uniform and enforceable measurement protocols. This was important because the actual pollution measurements would only be coordinated by and not actually carried out by the subcommittee. This was delegated to appropriate agencies in the riparian states themselves; in the Netherlands, for example, the *Rijkswaterstaat* took responsibility. Almost three years later, in May 1953, a second meeting of the commission authorised the subcommittee's hard-won proposal for a common measurement protocol and a month later officials at nine locations along the Rhine from the Bodensee to Vreeswijk got the green light for the first truly international survey of Rhine pollution. Assays of physical and chemical composition were taken every two weeks at different depths and positions across the breadth of the river.[54] Locations along the river were chosen so as to enable identification of which tributaries and stretches of the river (and ultimately which point sources) contributed to specific kinds of pollution. The results over the first two years, 1953 and 1954, were published in 1956 after ratification by the Commission. In its report the sub-committee concluded with some alarm that: 'In those stretches examined by the committee, and especially in its lower reaches, the Rhine is so heavily burdened (by pollutants, CD) that all means must be mobilised in order to improve the situation as quickly as possible'.[55]

However, the ICPR was nearly powerless in the face of the mighty economic forces behind pollution and the local and national governments that still privileged them over the interests of clean water. It lacked a charter, a base in international law and even, prior to 1953, a secretariat. In spite of this it had been able to clear enough diplomatic ground to be allowed to garner compelling quantitative evidence for the Rhine's polluted condition. Coupled to pre-war Dutch measurements, the new data presented a picture of long-term progressive deterioration of water quality across the board.

Meanwhile, back in the Netherlands, the riverine waterworks, led by Amsterdam and Rotterdam, had organised themselves in 1951 into the Rhine Waterworks Commission (RIWA). Against the background of the founding of the ICPR, the RIWA tacitly set itself up as a watchdog and a lobby organisation to ensure that the specific interests of downstream Rhine waterworks were represented in the international diplomacy on Rhine pollution. In 1958, Amsterdam's Municipal Waterworks finally commissioned the pipeline for recharging its dune water system with Rhine water.[56] In the same year the Dutch delegation to the ICPR submitted a specification for upper limits on a number of chemical and bacteriological pollutants in Rhine water where the river entered the country at Lobith. Although in view of the absence of any authoritative transnational body there was no hope of achieving these demands in the short term, the interests and commitments of the middle riparian states were nonetheless perceptibly changing. As in the Netherlands during the interbellum, municipal waterworks (sometimes allied with nascent environmentalist groups) played a prominent role in raising consciousness about pollution and in cajoling governments to take action. As early as 1950, directors of Swiss and German waterworks around the Bodensee met to discuss their mutual concerns about increasing pollution in the lake. In 1960 a treaty to protect the Bodensee was ratified by Baden, Bavaria, Switzerland and Austria. In order to ensure the tight standards essential to the economic production of high-quality drinking water, the Bodensee waterworks united in the Arbeitsgemeinschaft Wasserwerke Bodensee-Rhein (AWBR) in 1968. Like the Dutch RIWA, this branch organisation carried out its own (stringent) tests of water quality and was in general active in bringing the importance of clean water to the attention of politicians and the public. In 1958, Swiss and German waterworks on the upper and middle Rhine had also joined forces in the Arbeitsgemeinschaft Rhein Wasserwerke (AWR) – again an organisation similar in scope and intent to the RIWA and the AWBR. Hence, by 1963 enough of a consensus on the value of a clean(er) Rhine had emerged among the riparian states (among other things because German and French municipal waterworks and industries were also beginning to suffer the consequences of a polluted Rhine) for them to anchor the ICPR in an international treaty against Rhine pollution. This so-called Bern Convention empowered the ICPR to pursue all necessary research in order to establish the nature, degree and sources of pollutants; to advise the member governments of steps necessary to defend the Rhine against pollution; and, finally, to do the groundwork for possible agreements among the member states aimed at fighting pollution. As of 1969, at least in the opinion of the Dutch Association of Waterworks (VEWIN), the Commission had succeeded admirably on the first two counts, but had consistently baulked at the third point.[57] Negotiations within the ICPR were formal, polite and generally ineffective, especially when they concerned Dutch complaints about the salt effluents produced by the Alsatian potassium mines and the Ruhr coal mines.[58]

The citation heading this article, by the chief biologist of the Amsterdam Public Health Service, N.L. Isebree-Moens, may seem rather defeatist. Yet few devoted more effort to fighting Rhine pollution, both nationally and internationally, than this woman. Her apparent fatalism can only be understood as prudent realism, as accepting (without condoning) the fact that for the time being the only sensible posture of the Dutch toward Rhine pollution was to be prepared for anything – while simultaneously pursuing the goal of authoritative international effluent management. The degree of prudence inherent in this realism of course depended entirely on trust in the technological wherewithal of the Dutch waterworks. We have seen how the municipal waterworks of Amsterdam and Rotterdam managed to adapt their water sources and their purification processes to the gradually deteriorating quality of Rhine water. However, in the course of the 1960s, in addition to persisting worries about increased levels of physical, chemical and biological pollutants (especially salts) and new concerns about radioactive and thermal pollution, the waterworks began to have really serious doubts about the adequacy of their analytic toolboxes. The river increasingly began to be viewed as a complex 'chemical soup' whose composition was only partly knowable and which might well contain highly toxic components that could not even be detected by normal methods of analysis, let alone eliminated by standard waterworks purification processes. As a 1966 RIWA memorandum to the ICPR (containing data on Rhine pollution over the prior twenty years) stated:

> The data which are here taken to represent characteristic values do not in any way provide a complete picture of the pollution of the Rhine. Substances which can, even in microscopic amounts, strongly influence the water quality, such as for example inorganic and organic toxins … do not appear in these tables because they cannot be routinely detected.'[59]

These amorphous fears had antecedents in the mysterious episodes of bad taste and smell which had plagued the Rhine for over half a century, but in the 1960s they were heightened by visible incidents of toxic poisoning. The most spectacular was that caused by the accidental dumping of the insecticide Endosulfan by Hoechst Chemicals into the Main, a major Rhine tributary, in June, 1969.[60] If masses of fish could just up and die from one moment to the next, who was to say what kinds of toxins – perhaps in minute but nonetheless dangerous amounts – might be present in river water under 'normal' circumstances? For catastrophic episodes of poisoning like the 1969 Endosulfan incident, Isebree-Moens' posture of prudent realism came down to the ability to disconnect the waterworks from the Rhine at a moment's notice. This required persistent monitoring, an early warning protocol for upstream 'accidents', as well as alternative sources of water or sufficient storage capacity to tide over the toxic wave.[61] However, this did nothing to allay the Dutch waterworks' fear of undetectable and untreatable 'background toxins'. This could only be laid to rest by guarantees of prevention at the points of pollution.[62]

The Endosulfan incident and the fears it raised had two immediate effects. First, it confirmed the resolve of Rhine waterworks to fight for pollution control and the environmental regulation of the Rhine. After the incident, the Dutch RIWA intensified its contacts with the upstream waterworks associations and this resulted in the founding, in October 1969, of the basin-wide *Internationale Arbeitsgemeinschaft der Wasserwerke im Rheineinzugsgebiet* (IAWR) in which the RIWA, the AWR and the AWBR combined forces. Through the annual meetings and by means of lobbying and publicity, the IAWR enabled its 83 member Rhine waterworks to play the role of watchdog from a 'left-wing' position in the international manoeuverings around Rhine pollution. A second effect was that for the first time there was massive public unrest about the deteriorating quality of the Rhine's waters. As Amsterdam's Waterworks Director put it a month after the event:

> … never before in the history of the Rhine had there been a toxic episode coupled with massive fish starvation that so attracted public attention. The event was front page news for many days in a row. Questions were put in parliament … The problem of the Rhine as a *sick river in Europe* thus became visible for everyone. Not only for the experts who had long since and repeatedly been blowing the whistle. (italics -author's emphasis) [63]

The notion of a 'sick river in Europe' would prove to be an explosive idea in the decade to come. In this sense the Endosulfan event could be said to have occurred at a very auspicious moment, right in the take-off period of a heightened environmentalist consciousness. Throughout the 1970s national and regional governments built or helped subsidise the construction of numerous wastewater treatment plants. Even notorious polluters like the huge chemical firm BASF in Ludwigshafen invested capital amounts in new (and well-publicised) wastewater treatment plants and, very gradually, a number of indicators of pollution began to show a downward trend for the first time in nearly 100 years of measurements.[64] Although the Rhine waterworks could not yet relax their vigilance they could certainly be pleased by the emergence of a new environmentalist consciousness and the entrance of activist groups like Greenpeace or the Dutch group *Reinwater* into the fray. These groups represented a new radical left-wing opposition to Rhine pollution, essentially demanding zero-pollution on the basis of a variety of biological and ecological criteria. After the big Sandoz fire of 1986 such demands hardly seemed radical anymore. Sandoz provided the political space to envisage not merely a cleanup, but a total ecological restoration of the Rhine, embodied in the (originally Dutch) slogan: 'Salmon back in the Rhine'. In this new phase of the struggle to restore the Rhine, international environmentalist politics, carried out by national and transnational agencies, became a far more salient factor in cleaning up the Rhine than the collective agency of the Rhine waterworks, though of course these continued to defend their specific interests in the persisting tug-of-war around water quality on the river.

CONCLUSION: FLOWS AND TENSIONS

Behind this specific story about Dutch municipal water supplies and the Rhine lurks a vision of how 'Europe' has been constituted piecemeal around the building of various large technical systems and the management of the flows they contain. From this perspective, the larger question posed in this paper is how local actors couple and uncouple with the systems by managing or dealing with system flows, i.e. what local and cosmopolitan strategies they employ to adapt to the system or to get the system to adapt to them – and hence how they constitute an 'infrastructural Europe' in the process. In this story of localities coupling to the transnational water flow of the Rhine, Amsterdam's and Rotterdam's Municipal Waterworks employed different strategies. Rotterdam's Municipal Waterworks, coupled to the Rhine from its inception, struggled to manage purity by defending itself against the impacts of uncontrolled flows at the local level by means of continual improvements in purification technologies, alertness and opportunistic flexibility. Amsterdam, only 'virtually' committed to the Rhine system, attempted to negotiate and enforce favourable flows before making the (almost irreversible) decision to commit itself. Amsterdam's insistence on minimal quality guarantees long delayed its accession to the Rhine water supply system, but it also resulted in the first international efforts to assess and manage levels of pollution in the river. This story illustrates a number of points that may be salient for analysing other infrastructural constructions of Europe:

First, the paper shows that the transition of Amsterdam's water system from dune and lake catchments to the Rhine entailed a radical change in the governance arenas in which the municipal waterworks had to operate. While the exploitation of regional sources of supply required only bilateral negotiations with other municipalities or provincial authorities, extracting water from the Rhine compelled successive directors of Amsterdam's waterworks to operate first on a national and subsequently on an international stage. This was not simply a matter of giving voice to waterworks interests in the councils of already established governance institutions. It also entailed political entrepreneurship in search of new alliances and forms of leverage to constrain upstream polluters. This required an intermediate stage of national consolidation of Dutch Rhine waterworks interests in order to press the Dutch government to lobby at a European level for new instruments of transnational governance. And, though after World War Two the initiative had passed to the nation states – and in part to the nascent European Community – sustainable success required ongoing interventions from the organised Rhine waterworks to defend their sectoral interest in the biological and chemical purity of the river's water.

This raises a second point about large rivers as contexts for (or 'carriers' of) multiple flow-based technological systems. They share this characteristic with many types of carriers (for example roads, VHF cables, air corridors) although rivers seem to be uniquely heterogeneous in this respect. A major river like the Rhine simultaneously supports an inland shipping system, a water-supply system, a wastewater system, a hydroelectric power system, an ecosystem, and a system of tourist transport and destinations.[65] This makes rivers (and their flows) extremely intransigent objects of governance, not least because the various technological systems (or functions) interfere greatly with one another. As one might expect, the different systems have heterogeneous histories, based in different geographical and historical contexts. On the Rhine, for example, navigation has the oldest claims and has been an object of international regulation since 1815 when the Central Commission for Navigation on the Rhine was called into being by the Congress of Vienna. In this commission riparian nation states have expressly surrendered bits of sovereignty over the river with the common aim of establishing a uniform and free international navigational regime. Hence, under the umbrella of the willing (partial) suspension of national autonomy, shipping experts and shipping interests of the different riparian nations have for almost two centuries battled to create a workable and mutually profitable international artery of inland shipping. The salient point for this essay is that this did nothing whatever to improve the quality of the Rhine's water – rather the opposite. In order to deal with this issue the riparian nations had to be call themselves to order a second time, ironically in the first instance via their representatives in the Central Commission. This mobilised an entirely different assemblage of interests and experts – in some cases even sworn antagonists of those clustered around the Central Commission. But this meant that each participating nation-state also had to develop a polymorphous perspective on the river as physical context for contradictory technological systems. In the case of water supply this was clearly the result of national agitation by the internationally organised waterworks sector which convinced national governments to regard the river as not only a wet highway, but also as a flow of useful, because clean, water. Similar but as yet only bi- or multilateral organisations arose around developing hydroelectric power on the river. More recently, international projects like 'Salmon in the Rhine' and 'room for the river' (flood management) are also emerging and broadening the fronts along which an infrastructural Rhine and Europe are being built. This is reflected in the 1999 name change of the ICPR, in which the suffix 'against Pollution' was dropped to express the more universal nature of the 'protection' in the commission's mandate.[66]

These shifts in perspective and the international organisation and governance they made possible did not simply emerge out of thin air; they were the results of hard diplomatic and technological work. Dutch agitation for improved water quality in the Rhine dates from the 1930s, but acknowledgement of the legitimacy of the complaints took until the mid-1950s and it took at least another 20 years before major cleanup efforts were launched. In this domain, as in numerous others, the 1970s appear as an important watershed when the popular legitimacy of 'environmental' protection compelled the governments of nation-states to reconsider policy on a large number of fronts. It was a period in which demographers, chemists, biologists and ecologists – some of them in the employ of municipal waterworks – came out of the closet and began to analyse how modernist practices and cultures were destroying the natural environment and to present alternative scenarios for development. However, the *Sturm und Drang* of this period, full of colourful and exciting stories and big and little victories, should not lead us to think that environmentalism was invented only then. Its roots lay much deeper in the past and it might be more accurate to portray the 1970s as a time when, thanks to cultural changes and the efforts of a plethora of activist groups, environmentalism became politically correct, so much so that politicians could no longer afford to neglect environmentalist criticism of the policies they espoused. This is why the International Commission for the Protection of the Rhine against Pollution, founded in 1948 in a window of opportunity after the Second World War, was unable to make much headway in the European policy arena before the 1970s.

NOTES

The author thanks Arne Kaijser, Lissa Roberts, Adri Albert de la Bruheze, Fokko-Jan Dijksterhuis, Alette Fleischer and the anonymous referees of *Environment and History* for encouragement and helpful criticisms of earlier versions of this article.

[1] Isebree-Moens, 1956a.

[2] Tarr, 1998.

[3] For the United States see Cronon 1991, Melosi 2000, 2001, Tarr 1998; for Europe, Cioc 2002, Dieperink 1997, Van Simson 1978.

[4] Cioc 2002, Schott 2000.

[5] Schott 2000.

[6] Cited in Ibid. The three-man committee consisted of Max Honsell, chief engineer of Baden's prestigious Dept. of Hydraulic Engineering and Road Construction; Dr. Battlehner, Karlsruhe surgeon and public health expert; and Prof. August Gärtner, former assistant to Robert Koch. Gärtner was author of the influential *Die Hygiene des Wassers* (1915).

[7] Formally the committee was not competent to impose its will on Worms inasmuch as the committee had been appointed by the Grand Duchy of Baden and Worms was subject to the Principality of Hessen-Darmstadt.

[8] Cioc 2002.

[9] Ibid., Dieperink 1997.

[10] Groen, n.d.

[11] Between 1870 and 1890 Amsterdam's population increased from 265,000 to 408,000, i.e. by nearly 54%. The harbinger of the new hygienic 'water culture' was the water closet, adopted from British designs. Figures for Rotterdam indicate that in 1880 there were some 1,500 flush toilets for about 6,000 domestic water supply connections. By 1890 this had climbed to 6,000 flush toilets and nearly 11,000 domestic connections and by 1900 to 17,000 flush toilets and 17,500 domestic connections. Though the flush toilet certainly increased hygiene in the home and on city streets and canals, it was highly detrimental to the quality of the surface water on which municipal sewer systems, now increasingly laden with human wastes, invariably evacuated. See Wirtz 1924.

[12] Groen, n.d.

[13] The analyses were done by personnel of the Amsterdam Waterworks at a laboratory in the town of Amerongen on the Nederrijn. They included counts of suspended particles, assays of chloride and ammonia content, and the determination of the potassium permanganate index. The concentration of chloride ions is an indicator of salinity. The ammonia and permanganate tests established the degree of organic pollution (Biemond 1940). A similar set of measurements were taken in 1916 by the Government Institute for Public Water Supply.

[14] The determinations were made in a laboratory at Rhenen on the Nederrijn River and were very elaborate, comprising assays of no less than 27 different impurities, including hydrocarbons and heavy metals. See Heijmann 1931. Between 1932 and 1938 a second more modest series of measurements (which, however, now also included phosphates) were taken at a laboratory in Vreeswijk.

[15] Van Royen, 1938, 153.

[16] Untreated river water was the traditional source of potable and household water in Rotterdam. In fact, the practice of drinking the (free and easily accessible) river water persisted even after the institution of a public water supply and in full knowledge of the local pollutants that entered the water. A British yachtsman moored at Rotterdam reports the following scene from the mid-1880s: 'The (harbour) basin was very impure to look at, but the people drank the water, and we saw a bucket of slops being emptied over at one end of a barge, while at the other a girl was letting down a small copper bucket and drinking out of it. But impure as it seems, the river water is drunk by all Rotterdam. We had to fill up our tanks here, out of a water boat which came alongside. The water she brought was fairly clear, and had probably been partly purified' (Davies 1886). Getting Rotterdammers to drink purified mains water seems to have been the object of a tenacious and difficult civilising mission as this 1909 newspaper item attests: 'One of the labour inspectors in the harbour determined that workmen on board the SS Dartmoor were using river water as drinking water because the water from the ship's pump had an unpleasant taste and smell. Efforts were made, but to no avail, to provide the labourers with municipal mains water'. *Nieuwe Rotterdamsche Courant*, Saturday 15 July 1909, Ochtendblad B.

[17] *Nieuwe Rotterdamsche Courant*, 14 March 1912. vol. 69. Andere Steden

[18] Presumably this would have involved the addition of alum, to precipitate out suspended organic matter followed by chlorination, to kill bacteria. It was clearly fears of bacteriological infection that motivated the Health Commission to advocate chemical purification.

[19] Van der Noort and Blauw, 2000. The 'Maas' here should not be confused with the Meuse, which in Dutch is also called the Maas. The Nieuwe Maas in Rotterdam is (at least at present) a branch of the Rhine.

[20] Dieperink 1997.

[21] Wirtz 1924.

[22] The Government Bureau for Waterworks (Rijksbureau voor Drinkwatervoorziening) was established in 1913 as the technical agency of the Central Commission for Waterworks (1911) to offer engineering consultancy services to regional (i.e. non-urban) waterworks. Its main task was to stimulate the introduction of public waterworks to the countryside. In time it also became instrumental in coordinating the production of drinking water at the national level.

[23] Cioc 2002, Rijksinstituut voor Hydrografisch Visserijonderzoek 1919.

[24] The fisheries inspector ascribed the heightened fish mortality to the disease *furunculosis* on the basis of the characteristic boils found on dead fish. However, efforts at positive identification of the disease by isolating its characteristic microbe (*Aeromonas salmonicida)* foundered on the state of putrefaction of the specimen fish. This was due to the fact that the dead fish were only normally discovered and collected after floating to the surface, i.e. as a result of being bloated with gas by the onset of decomposition. The fisheries investigation is described in the *Annual Report of the Rijksinstituut voor Hydrografisch Visserijonderzoek*, Appendix D, 1918, reprinted as 'Vischziekte en Verontreiniging van het Rijnwater' in *Water, Bodem, Lucht* 9 (Rijksinstituut voor Hydrografisch Visserijonderzoek 1919).

[25] Rijksinstituut voor Hydrografisch Visserijonderzoek 1919.

[26] Ibid.

[27] Repeated efforts to identify the fungus by cultivating it on nutrient substrates failed because it no longer had the ability to produce spores and reproduce.

[28] Rijksinstituut voor Hydrografisch Visserijonderzoek 1919.

[29] The German reports also identified the fungus as *Sphaerotylus Natans*, to which the shreds found in the Lek bore a 'strong resemblance' according to the report of the fisheries inspector. See Gärtner 1915.

[30] Rijksinstituut voor Hydrografisch Visserijonderzoek 1919.

[31] *Nieuwe Rotterdamsche Courant*, 28 December 1921, Ochtendblad B, p. 1

[32] *Nieuwe Rotterdamsche Courant*, 6 January 1922, Letters to the Editor, Avondblad A

[33] Ibid.

[34] Another letter-writer, 'Chemicus', offered more esoteric remedies:

> If one mixes Rotterdam's water with a bit of Norit (a pure carbon antacid pill) and filters it through filter paper placed in a funnel, taste and smell will become normal.
>
> A second remedy, less effective but still a great improvement, is blowing air through the water, which can be accomplished, for example, by using a bottle with a two-holed cork. A glass tube is passed through one of the holes and comes out near the bottom; a short glass tube is passed through the second hole which is used to suck air, e.g. with an air pump. Those having access to an electric vacuum cleaner could use this as an air suction apparatus.
>
> This method could also be implemented on a large scale without unduly high costs. (*Nieuwe Rotterdamsche Courant*, op. cit.).

Grass-roots inventiveness like that exhibited by Haas and Chemicus was an abiding feature of Rotterdam's long struggle with polluted Rhine water and developed into a kind of consumers' culture for surviving bad water.

[35] The committee included representatives of the municipal waterworks of Amsterdam, Rotterdam and Dordrecht, of the Pharmaceutical Chief Inspectorate of Public Health, the Central Laboratory for Public Health, the Central Commission for Waterworks, the Government Bureau for Waterworks, the Government Institute for the Purification of Wastewater, the Dutch Association of Waterworks, and a vocal but not very influential environmentalist group, the Dutch Society against Soil, Water and Air Pollution.

[36] Biemond 1940. Heymann, in charge of Amsterdam's Rhenen laboratory, attributed the bad taste to the phenol-laden wastewater of the Emscher, basing his case on the fact that the bad taste ceased suddenly on the occasion of a major strike in the Ruhr in November 1928 and with the inauguration of a huge wastewater treatment plant on the Emscher shortly thereafter. Heijmann 1931.

[37] Dieperink 1997.

[38] Other waterworks were less stern. The Commission on Taste and Smell of River Water eventually compromised on 150 mg/litre as the maximum allowable chloride concentration.

[39] Mark Cioc (2002) devotes most of a chapter in his book on the Rhine to an incisive account of the division of labour between the three main right-bank Westphalian tributaries of the Rhine, the Ruhr, the Emscher and the Lippe. In an effort to maintain water quality in the Ruhr and the Lippe, the Emscher was designated the common sewer for both industrial and municipal effluents of the entire Ruhr region. The Rhine – into which

the Emscher's polluted waters flowed – was considered an inexhaustible 'ultimate sink', presumed capable of diluting, dispersing and breaking down the Emscher's poison – an opinion with which the Dutch soon found reason to disagree.

[40] This was an apposite metaphor, because the main chloride threat came from the sea via the brackish tidal river estuaries. This could only be countered by generous flushing with 'fresh' Rhine water. The saltier this got, the less effective the flushing became.

[41] Dieperink 1997.

[42] The IJsselmeer was a large new freshwater lake formed by the closing off of the Zuiderzee with a sea-dike. The lake, formally fresh in 1936, was fed by the IJssel, a branch of the Rhine. Because of self-cleansing, it was in all respects but salinity a more acceptable drinking water source than the Rhine itself. However, the salty water pumped out from the newly reclaimed lands (*polders)* along its shores, raised its chloride content even higher even than that of the Rhine. Although the Commission for Waterworks in the Western Portion of the Country was optimistic about the IJsselmeer as a future source of drinking water, it was rejected out of hand by the Amsterdam Waterworks. This left Amsterdam with only the Rhine itself as a long term option.

[43] Van Royen (1933) is a bit tendentious here. A number of German cities, particularly along the upper and lower Rhine, did use Rhine water, but only indirectly in the form of what was called *Üferfiltrat*. In this procedure the water was not extracted directly from the river, as at Rotterdam, but pumped out of the gravel and sand layers adjoining the river. This may in fact have inspired Amsterdam's dune infiltration plan.

[44] In effect, the collective abandonment of the Rhine as a source of fresh water by upstream municipal and industrial waterworks ironically degraded mythical 'Father Rhine' to the status of an Emscher writ large. See note 39.

[45] Van Royen 1933.

[46] Kosman 1988.

[47] Krul 1959.

[48] Aalberse 1940.

[49] Rijksinstituut voor de Zuivering van Afvalwater

[50] Jaag 1956, Lillinger 1977.

[51] Jaag 1956.

[52] Lillinger 1977.

[53] Jaag 1956

[54] Isebree-Moens 1956b.

[55] Ibid.

[56] The term 'recharging' usually applies to artificially supplying an aquifer with supplementary water from some surface source. The dunes from which Amsterdam's waterworks extracted fresh raw water by deep-pumping were not an aquifer in the sense of a porous layer that transported water in a horizontal direction over great distances. The dunes were more like an underground catchment for local rain water and were in fact isolated from their hydrological surroundings by packets of deep saline groundwater. The fresh water floated, as it were, on top of the saline water layers. 'Recharging' here was a form of irrigation of surface canals whose waters gradually seeped down into the sand mass (and in the process were filtered and purified) as raw drinking water was extracted from the bottom of the fresh water 'sack.'

[57] Van der Veen 1969. The VEWIN, the Association of Waterworks in the Netherlands, was founded in 1954 as a lobby organisation for Dutch waterworks. It was not a major actor in Rhine drinking water politics because this role had already been preempted by the RIWA, the Rhine Waterworks Association, founded three years earlier in 1951. The VEWIN was a specialised offshoot of the Association of Waterworks Concerns (VWN) founded in 1899. The VWN was both a lobby organisation for municipal and regional waterworks as well as a technical society for sharing knowledge and experience among the members. To this latter end it maintained a journal, *Water,* containing contributions on all aspects of waterworks technology and management. Articles were also published on the special problems of river waterworks and on the water quality of the Rhine. There is no indication, however, that the VWN as an organisation lobbied against surface water pollution or played any role in national or international politics relating to extracting drinking water from the Rhine.

[58] Dieperink 1997.

[59] Van der Veen 1969.

[60] Ibid.

[61] Rotterdam's waterworks, for example, which had long postponed building extensive storage basins for financial reasons, finally came around in 1967 when plans were made to build large storage reservoirs in the Biesbosch, at the confluence of the Meuse and the major Rhine branch, the Waal. The location had the added advantage that water could also be drawn from the Meuse, thus finally ending Rotterdam's century-long sole dependence on the Rhine.

[62] In fact investigation into the Endosulfan incident by Dutch researchers showed that Hoechst illegally dumped about 40–50 kg. of Endosulfan-related wastes into the Main every day. Minute Endosulfan concentrations proved to be 'normal' all the way to the mouth of the Rhine. Cioc 2002.

[63] Van der Veen 1969.

[64] Heinz 1977.

[65] Disco and Van der Vleuten 2002.

[66] The name change was subsequent to the revised Rhine Convention signed at Bern on 12 April 1999, in which the commission was mandated not only with protecting the Rhine against pollution, but also with protecting its ecology and protecting its environs against flood damage.

REFERENCES

Aalberse, P.J.M. 1940. *Rapport van de Commissie Drinkwatervoorziening Westen des Lands*. The Hague: Algemeene Landsdrukkerij.

Biemond, C. 1940. *Rapport 1940 inzake de watervoorziening van Amsterdam*. Amsterdam: Gemeentewaterleidingen Amsterdam.

Biemond, C. 1948. *Rapport 1948. De Watervoorziening van Amsterdam*. Amsterdam: Gemeentewaterleidingen Amsterdam.

Cioc, M. 2002. *The Rhine: An Eco-Biography, 1815–2000*. Seattle: University of Washington Press.

Cronon, W. 1991. *Nature's Metropolis. Chicago and the Great West*. London: Norton.

Davies, G.C. 1886. *On Dutch Waterways. The Cruise of the S.S. Atalanta on the Rivers and Canals of Holland and the North of Belgium*. London: Jarrold and Sons.

Dieperink, C. 1997. *Tussen zout en zalm. Lessen uit de ontwikkeling van het regime inzake de Rijnvervuiling*. Amsterdam: Thesis Publishers.

Disco, C., and Vleuten, E.v.d. 2002. 'Water system building in national-historical perspective: The politics of wet system building: Balancing interests in Dutch water management from the middle ages to the present'. *Knowledge, Technology and Policy,* 14(4), 21–40.

Gärtner, A. 1915. *Die Hygiene des Wassers : gesundheitliche Bewertung, Schutz, Verbesserung und Untersuchung der Wässer : ein Handbuch für Ingenieure, Wasserwerksleiter, Chemiker, Bakteriologen und Medizinalbeambte*. Braunschweig.

Gelpke, R. 1919. *Free Access to the Sea for Switzerland and The Rhine a Highway of British Trade*. London: s.n.

Groen jr., J.A. n.d. *Een cent per emmer. Het Amsterdamse drinkwater door de eeuwen heen*. Amsterdam: Gemeentewaterleidingen.

Heijmann, J.A. 1931. 'De Rijn als toekomstige bron der drinkwatervoorziening van Amsterdam'. *Water,* 13, 14, 15, 118–120; 131–135; 141–149.

Heijmann, J.A. 1932. 'Nog enkele gegevens betreffende de samenstelling van het water van de Rijn'. *Water,* 16(21/22), 219–221; 227–229.

Heinz, V., ed.1977. *Gewässerschutz am Rhein*. Köln: Verlag Wissenschaft und Politik.

Isebree-Moens, N.L. 1956a. 'De betekenis van de verontreiniging van de Rijn voor de Hollandse waterhuishouding'. *Water, Bodem, Lucht,* 46(4), 103–110.

Isebree-Moens, N.L. 1956b. 'Internationaal onderzoek naar de mate van vervuiling van het water van de Rijn'. *Water, Bodem, Lucht,* 46(3), 52–57.

Jaag, O. 1956. 'Internationale vergadering tegen watervervuiling te Meersburg'. *Water, Bodem, Lucht,* 46(4), 98–102.

Kosman, H. 1988. *Drinken uit de plas 1888–1988. Honderd jaar Amsterdamse plassenwaterleiding*. Amsterdam: Gemeentewaterleiding Amsterdam.

Krul, W.F.J.M., ed.1959. *De waterhuishouding van Nederland*. The Hague: Moermans Periodieke Pers.

Lillinger, R. 1977. *Der Rhein - ein europäischer Strom. Zusammenwirken von Rheinschutzcommission, Europäischer Gemeinschaft und Europarat zur Erhaltung des Rheins*. Cologne: Verlag Wissenschaft und Politik, Berend von Nottbeck.

Melosi, M. 2000. *The Sanitary City: Urban Infrastructure in America from Colonial Times to the Present*. Baltimore: Johns Hopkins University Press.

Melosi, M. 2001. *Effluent America: Cities, Industry, Energy and the Environment*. Pittsburgh: University of Pittsburgh Press.

Noort, J.v.d., and Blauw, M. 2000. *Water naar de zee. Geschiedenis van Waterbedrijf Europoort*. Rotterdam: NV Waterbedrijf Europoort.

Rijksinstituut voor Hydrografisch Visserijonderzoek. 1919. 'Vischziekte en verontreiniging van het Rijnwater'. *Water, Bodem, Lucht,* 9, 110–120.

Royen, R.v. 1933. 'Oppervlaktewater als bron voor waterleidingen'. *Water, Bodem, Lucht,* 23, 88–98.

Schott, D. 2000. Remodeling 'Father Rhine:' The Case of Mannheim 1825–1914. In Anderson, S.B., and Tabb, B.H., eds., *Water, Culture and Politics in Germany and the American West*. New York: Peter Lang, 203–225.

Simson, J.v. 1978. 'Die Flußverunreinigungsfrage im 19 Jahrhundert'. *Vierteljahrschrift für Sozial- und Wirtschaftsgeschichte,* 65, 370–390.

Tarr, J. 1998. *The Search for the Ultimate Sink: Urban Pollution in Historical Perspective*. Akron: University of Akron Press.

Veen, C.v.d. 1969. 'De visvergiftiging op de Rijn in juni 1969'. *De Ingenieur,* 32(8 augustus), A503-A508.

Wirtz, F.F.M. 1924. *De watervoorziening van Rotterdam*. The Hague: Moermans Periodieke Pers.