The View from Below: Dutch Riverine Waterworks and the Struggle to Clean up the Rhine 1925-1975

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Abstract

From 1900 on, the Amsterdam waterworks had periodically considered plans for extracting raw water from the Rhine, but these repeatedly foundered on the results of chemical and biological assays of Rhine water and episodes of visible (and tastable) pollution. Amsterdam's aversion to the Rhine impelled it to seek alternative sources of water in its immediate environs until these had proved structurally inadequate and the Rhine pipeline was finally commissioned in 1958. Meanwhile Rotterdammers had been drinking Rhine water with impunity since 1874, trusting to purification technologies and chemicals to render the Rhine's water safe. But it was precisely Amsterdam's covetous but fastidious attitude toward the Rhine that propelled it into national and international Rhine politics and helped launch the big cleanup starting in the 1970s. Amsterdam's waterworks took the lead in fostering common vigilance among Dutch Rhine waterworks as early as the 1930s. After WW2 the Dutch Rhine Waterworks Commission, with Amsterdam again in the lead, agitated to get pollution-control on the international Rhine agenda. This lead directly to the founding, in 1950, of the International Committee for the Protection of the Rhine against Pollution and, from the early 1970s, to a transnationally coordinated campaign to restore the river. The conclusion is that, as they expanded, local urban waterworks become increasingly enmeshed in the techno-politics of national and international bodies of water, especially rivers. In the case of the industrialized Rhine this produced acute downstream dependencies in regard to water quality. To the extent that local water sources and "technological fixes" were insufficient to ensure cheap, high-quality, water, new national and transnational governance arrangements had to be pursued by the "plaintiff" cities to protect their interests. This may well be a generic pattern for all kinds of urban infrastructure.

The Rhine and its Cities

"The Netherlands are the lowest lying region on the Rhine and we simply have to accept what Father Rhine gives us." (Wibaut Isebree-Moens 1956).

Relations between rivers and the cities along their banks are many-sided and contradictory. Rivers and cities shape each other incessantly. One important facet of this co-evolution is water quality. Cities are concentrations of population and industry and are hence both large-scale consumers of clean water as well as major producers of polluting effluents. However, these two contradictory roles have different salience for upstream and downstream cities. Downstream cities tend to bear the brunt of upstream pollution and have to develop strategies to deal with this disadvantaged position. They are, statistically, the plaintiffs in disputes over water quality. When rivers fall under different jurisdictions, as among states in the United States or among nations as in the case of the Rhine and many other large rivers, such conflicts have a capacity for developing into political imbroglios.

However, seeking to change the behaviour of upstream polluters is not the only option available to downstream consumers of water. Alternative strategies are, first, exploiting alternative sources of water and, second, the pursuit of new technologies of water purification. Along the Rhine, upstream as well as down a mix of both strategies was the prevalent solution for most of the twentieth century. 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 (Cioc 2002; Dieperink 1997). 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 failed to do so in earlier periods.

Amsterdam and Rotterdam: Purity vs. Purification

Amsterdam: purity

On June 14th, 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 drink water spout out of a fountain." (Groen n.d.) The water had been captured in a network of drainage canals in the coastal dunes west of the town of Haarlem, fed into a reservoir, and 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 beginning of piped water in Amsterdam – and indeed in the Netherlands as a whole. In the following years the dune water system gradually replaced the existing heterogeneous system based on rain barrels and the transport of water by barge from outlying lakes.

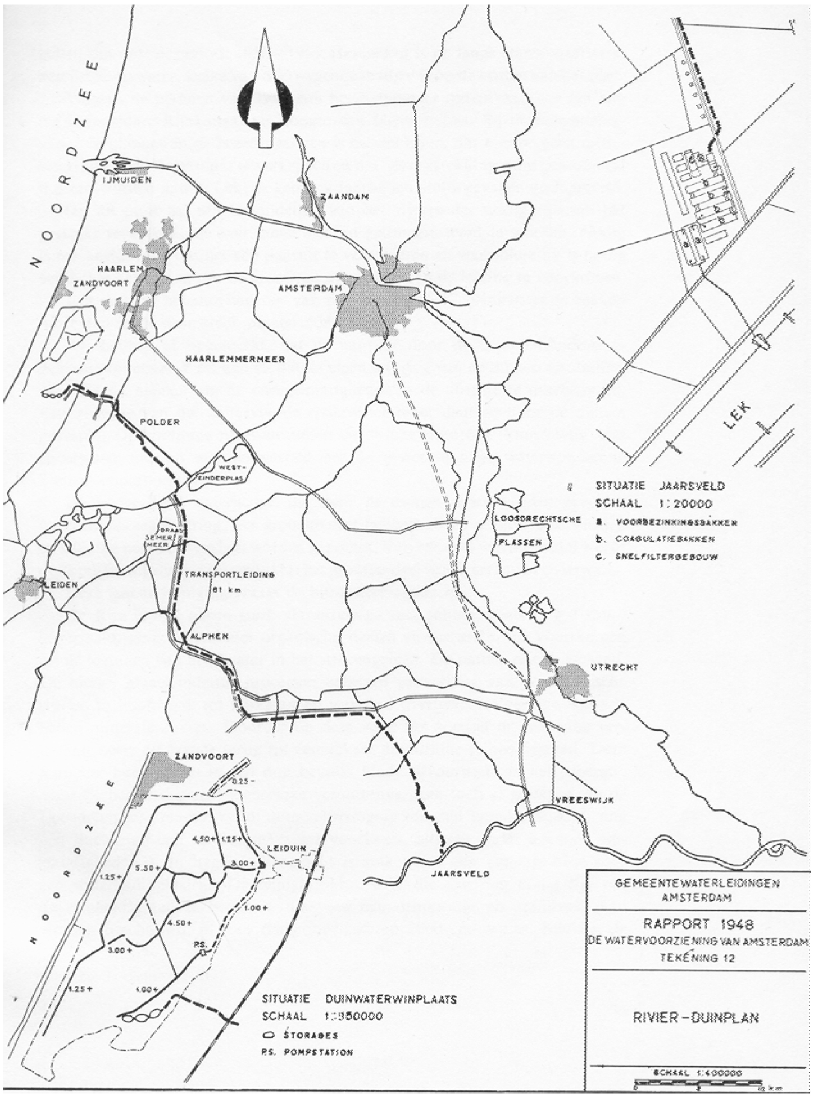

Figure 1: Amsterdam Waterworks showing proposed 1948 pipeline. The Lek River is at the lower right. The two insets are detail maps of the dune water catchment area (lower left) and of the proposed purification plant at Jaarsveld on the Lek River (middle right). Source (Biemond 1948).

But the rapid population growth that set in after 1870, along with the slow but sure development of a new hygienic "water culture," soon overtaxed the revolutionary dune water system inadequate[1]. In hot summers the company was unable to maintain pressure, causing faucets on upper floors to run dry. In 1885 the Dune Water Company was granted a concession by the city to extract water from the river Vecht, east of Amsterdam. However this river was burdened by sewage from the city of Utrecht and the Municipal 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 no palliative for the scarcity of potable water.

The chronic water shortage and the consequent frictions between the city council and the Board of Directors of the Dune Water Company moved the city to buy the company out in 1896. Soon after, a search for new sources of water was undertaken. In addition to digging trial wells in the downs east of the town of Hilversum, attention also turned to the Rhine, a branch of which passed Amsterdam at a distance of 60 km. In 1898 a series of measurements were taken to assess the suitability of the Rhine for drink water production.[2] In January, 1901, three options were proposed by the new waterworks director: extracting groundwater from the Hilversum downs, piping Rhine water directly in to the city (after artificial filtration) or "infiltrating" it first into the dune water system. The idea of the latter option was to let the natural dune filtration do the preliminary work of purification after which a final round of slow sand filtration, aeration and storage would produce potable water.

But the city council baulked at the high costs and succumbed to a cheaper proposal advocating deep well extraction of groundwater in the dunes. This "emergency" measure alleviated the immediate shortage so that a new prise d'eau on the Rhine seemed less urgent. Although by 1916 the city board had come down in favor of the infiltration option, high wartime prices for construction and stringent water conservation measures allowed for further postponement. In a report presented in December, 1924, no fewer than 7 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. New investigations were launched, among others into the quality of Rhine water. These were taken daily over a series of years, between 1927 and 1932, and included efforts to identify specific sources of pollution in the Ruhr-area by deduction from the nature of the pollutants and correlating changing pollution levels with upstream events like strikes and holidays.[3]

Rotterdam: purification

While Amsterdam's fastidious Municipal Waterworks had gotten no further than dipping an exploratory toe into the Rhine, Rotterdammers had been blithely drinking its waters since the construction of their own municipal waterworks in 1874. Originally the Municipal Health Commission, in view of the proximity of upstream cities and indeed of Rotterdam's own sewage outlets, had agitated for a dune water system and failing this, advocated (expensive) chemical purification of the river water.[4] But a committee of experts proclaimed this unnecessary, announcing that even without chemical purification the Maas could deliver "good and usable drinking water for everyone."[5] (Noort and Blauw 2000) So current best practice for treating surface water was adopted: precipitation in short term storage basins followed by biological sanded filtration. Part of the Health Commission's worries had been due to the tidal nature of the Maas at Rotterdam, which meant that every 12 hours or so the direction of the current changed and that hence there was no inviolable "upstream" location for a prise d'eau. In order to prevent the city's own sewage from entering the waterworks inlet, the "upstream" intake sluice could be opened only for a brief period after high tide when the current was decidedly seaward. Rotterdam's water intake proceeded in the form of huge and precisely timed gulps every twelve hours.

Several episodes of waterborne typhus and other infections kept the idea of chemical purification alive. 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 several episodes of a "carbolic acid" taste to their drinking water. This was just a few years after the first "carbolic tasting" Rhine salmon had been reported (Dieperink 1997). While the bad taste in Rotterdam went away again, suspicions did not. The Rhine looked less and less trustworthy, particularly when the river discharge was low and there was less water to dilute the pollutants. No one knew what caused the bad taste and who or what was responsible – although the finger was inevitably pointed at large chemical firms in the Ruhr.

Meanwhile, demand in Rotterdam increased as the post WW1 depression gave way to renewed prosperity. Given limited space on 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 pleasingly compact, the two filters could not provide adequate purification. A second stage was required. For this second stage it came down to a choice between accelerated filtration through the hitherto "slow" beds or chemical purification – in particular chlorination. (Wirtz 1924) As before, the waterworks shied away from chemical methods and opted for accelerated filtration through the slow sand filters. However, additional "carbolic acid" episodes during the cold winter of 1929, to which I will return below, finally overcame the ingrained preference for "natural filtration" and by 1931, when the new fast filters actually came on line, chlorination was added as well.

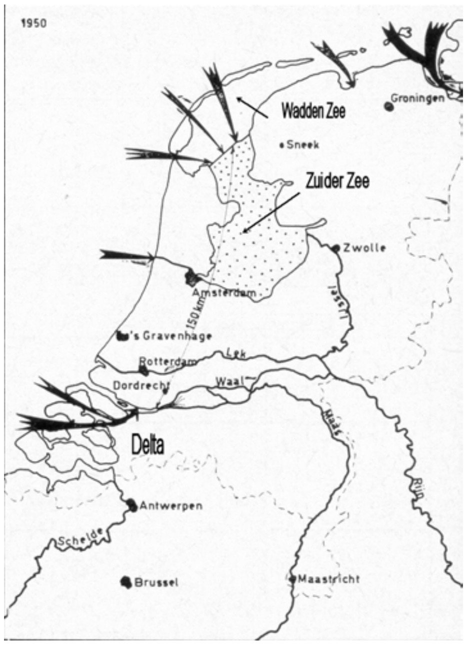

Figure 2: Netherlands showing course of Rhine, Scheldt and Meuse Rivers. Source (Hol 1963).

The Taste and Smell of River Water

In 1916, as a response to the 1911 episode of "carbolic acid" taste, the Government Office for Waterworks carried out a series of chemical and bacteriological assays of water in the Lek River (see fig. 1 and 2). Based on the usual determinations of dissolved salts and organic matter, the conclusion was that the water was not polluted and therefore eminently suitable for waterworks processing. 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 "sacrificed" to industrial and urban pollution, sustained suspicions about the quality of Rhine water (Cioc 2002; Rijksinstituut voor Hydrografisch Visserijonderzoek 1919). In 1917 this prompted the Government Institute for Hydrographic Fisheries Research to investigate possible causes of fish disease and starvation, with as primary suspect polluted river water. While the outcome of the 1916 investigations seemed to preclude this link, the anomaly was resolved when the attention of the Fisheries researchers was drawn to the bottommost layers of water by a grayish substance clinging to the bottoms of salmon nets and which fishermen described as rotted paper (Rijksinstituut voor Hydrografisch Visserijonderzoek 1919). Previous analyses had concentrated on surface water and on water layers several meters from the bottom. Now it became evident that on occasion the bottommost layers of water transported not only the grayish substance, but also "all kinds of refuse, like potato peels, vegetables, shreds of paper and leaves." (Rijksinstituut voor Hydrografisch Visserijonderzoek 1919). Upon analysis, the grayish substance turned out to be 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. The riddle was partly solved when it became apparent 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." (Rijksinstituut voor Hydrografisch Visserijonderzoek 1919). 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 latter, given the wartime situation, were not overly fastidious about their effluents. The fisheries investigator concluded that during periods of high water and swift currents these fungi were torn from the river bedding and swept downstream. Once the system had been "flushed out" and the river returned to normal, the waterborne shreds of fungi temporarily disappeared. Hence their prevalence in the spring when annual melt water increased the current in the Rhine. The investigator also saw a link with the occasional "carbolic acid" taste of the river water and salmon, although he was uncertain about the etiology. The overall 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" (Rijksinstituut voor Hydrografisch Visserijonderzoek 1919).

With these investigations the Dutch government had became engaged with the problem of Rhine pollution and began to identify it 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 Rhine's upstream reaches, particularly in heavily industrialized 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, Rhine pollution and hence foul-tasting water and fish starvation temporarily abated, fostering downstream complacency. However, by the end of the 1920s the combination of increasing demand for clean drinking water and increasing dependency of waterworks on river water along with palpably increasing Rhine pollution again brought the issue to the fore.

Starting in 1927 a number of parallel developments served to couple the local concerns of waterworks with a concerted national effort to chart Rhine pollution and to do something about it at an international level. In that year the director of Hamburg's Municipal Waterworks sent a letter to the Dutch National Bureau for Waterworks describing episodes of bad water taste 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 an interdepartmental broad-based "Commission for Taste and Smell of River Water" to investigate conditions on the Rhine.[6] Earlier, as noted, Amsterdam had started a Rhine water analysis program at Rhenen. The Taste and Smell Commission provided an important forum for the diffusion of the Amsterdam findings and analysis protocols 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 "carbolic acid" taste sorely tried the patience of water consumers in Rotterdam and other nearby riverine waterworks (Biemond 1940).[7] These episodes of bad taste prompted the Committee on Taste and Smell to undertake its own series of extended measurements on the main Dutch Rhine branch, the Waal, starting in March, 1931 (Dieperink 1997). The commission concluded that Rhine pollution was decidedly increasing but, no more than Amsterdam's chief chemist, Heymann, was it able to provide a satisfactory biochemical explanation for the "carbolic acid" taste. As Heymann had demonstrated, bad taste and smell appeared to correlate poorly with other indicators of organic and inorganic pollution. However these indicators were alarming enough for the commission researchers to refuse to actually taste unprocessed Rhine water during their measurement campaigns.

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 technically eliminated in a cost-effective fashion and can therefore render a body of water utterly useless as a waterworks source. Up to 1931, though the secular increase in salinity was alarming enough, it did not yet on average exceed even Amsterdam's stringent norm of 100 mg of chloride per liter.[8] The main suspects had been the effluents from the Westphalian coal mines which entered the Rhine via the Emscher and the various municipal sewer systems along the river. But in 1931 it transpired that the French government was about to grant its Alsatian potassium mines a concession to dump their waste salts – which until then had been stored in huge mounds near the mines – into the Rhine. Although the concession entailed stringent rules about how much salt could be dumped per day in relation to the momentary flow of the Rhine at the point of discharge, the Dutch waterworks considered any increase in Rhine salt levels as a "stab in the back."[9] Thanks to the Commission on Taste and Smell of River Water, the matter could be represented as a national problem (as opposed to a problem for a specific municipal or regional waterworks) and the appropriate diplomatic channels mobilized. However, the reasoned protests of the Dutch ambassador in Paris met with little sympathy from the French. In March, 1933, the Commission on Taste and Smell therefore delegated two of its members, W.F.J.M. Krul, the influential director of the Government Office of Waterworks and R. van Royen, director of the Amsterdam Waterworks, to Paris and Alsace to speak informally with the main French protagonists and to assess for themselves the gravity of the situation. Their conclusion was that the original Dutch response had been overly alarmist. Due to technical limitations in processing the waste salts, limited production because of the depression and increased international competition on the potassium market, the salt effluents would be less than originally estimated and would raise the level of salinity at Lobith (where the Rhine enters the Netherlands) by only 20mg/liter – serious but not yet deadly (Dieperink 1997) .

A further impetus for the nationalization of the drink water question in this period derived from the activities of the so-called Commission for Waterworks in the Western Portion of the Country (Commissie Drinkwatervoorziening Westen des Lands) appointed in 1931. Heavily urbanized and industrialized, and threatened with increasing saline intrusions from the sea, this "western portion" hung in the balance between its traditional dependence on finite but pure dune water resources and a future in which plentiful but suspect Rhine water loomed large. Rotterdam had skipped the "groundwater phase" and was in this respect already in the vanguard, fighting Rhine pollution for better or worse with up to date purification technology. Amsterdam, as we have seen, remained in an agony of indecision: loathe to compromise its comfortable and relatively 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 drink water, including the newly reclaimed IJsselmeer and the Rhine[10]. In its report of 1940, the commission concluded that these latter two sources, however troublesome, were the only feasible future 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 organized Dutch waterworks were deeply interested in exploring possibilities for regulation of upstream pollution. The French response to complaints about salt dumping were not at all encouraging and German polluters were scarcely less cooperative. The depression of the thirties had little effect on 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 (note 7), brought some relief, but after 1936, when the Rhine became enrolled into Hitler's war machine, the condition of its waters deteriorated again. Leverage on Germany in the 1930s was hard to get. 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" (Royen 1933).[11] 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.[12] 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 gotten as much attention as the fish. One can find no regulations in which the interests of public water supply are mentioned" (Royen 1933).

In response to the episodes of foul-tasting water in 1929 as well as the laconic attitude of upstream polluters both Rotterdam and Amsterdam took matters into their own hands again and turned their waterworks into the drink water equivalent of an armed fortress. For Amsterdam this meant enrolling alternative supplies of raw water not directly dependent on the Rhine; for Rotterdam upgraded purification technologies and much larger storage buffers offered the only long-term solution. Amsterdam succeeded in at least temporarily circumventing the Rhine by developing a new source for its old non-potable Vecht River Waterworks in the Loosdrecht Lakes west of Hilversum (see fig. 1). These were fed partly by Vecht water and partly by groundwater seepage from a large aquifer under the Hilversum Downs. Purification was effected partly by 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 tide over the increasingly frequent periods when the river water tasted badly. Given the fact that pollution concentration varied with the Rhine's overall discharge – a supplementary strategy being considered was the construction of large storage basins at some distance from the city. These could save water withdrawn from the river under favorable conditions for later use during periods of high pollution.

The International Arena: Coming to Grips with Pollution on the Rhine – after a Fashion

During the Second World War, the Rijkswaterstaat, the Dutch Hydraulic and Public Works Agency, developed the notion of the "national water household." The idea of the "water household" was that on the basis of an inventory the freshwater needs of industry, shipping, agriculture, waterworks, and water-level management measures would be devised for the equitable distribution of freshwater throughout the country and across sectors (Krul 1959) . 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 (Biemond 1940; Centrale Commissie voor de Drinkwatervoorziening 1940). In its new role as national freshwater manager, the Rijkswaterstaat became the central focus for formulating Dutch freshwater requirements in regard to the quantity and quality of Rhine water and in representing these requirements in international forums. Moreover, in 1945 the Rijkswaterstaat's expertise in the domain of pollution control was considerably bolstered by the incorporation of the RIZA, or State Institute for the Purification of Wastewater.[13] By 1947 the Rijkswaterstaat had instituted its own regular program of assays of Rhine water quality at several sites along the Dutch Rhine branches.

Meanwhile the ongoing monitoring of the Rhine by Amsterdam and the Dutch riverine waterworks showed by 1946 that, after a significant dip in the last two years of the war, levels of Rhine pollution were again rising at a spectacular rate as the postwar German and French economies got into gear. It was clear that if nothing was done, the Rhine would soon be dirtier and saltier than ever before. This was especially trying for Amsterdam, which was again turning to the Rhine. In bulky reports submitted in 1940 and in 1948, Amsterdam's waterworks concluded that piping Rhine water into Amsterdam's existing dune waterworks was among all the available options, the one best way. Calculations for different alternative plans showed that, with sufficient storage capacity to allow for natural purification and to tide over periods of poor river water, it would be possible to ensure adequate high-quality water for years to come. However, though the report did not say it in as many words, it was essential that Rhine pollution, particularly inorganic pollution – including salts – remained below certain specified levels. The value of major investments in new waterworks facilities and indeed the fate of much of the Netherlands' future water supply hung in the balance and was at the mercy of the wastewater policies of the upstream riparian powers.

Utilizing the excellent liaison with the Rijkswaterstaat that developed in the 1930s and during the war, Amsterdam took the lead in pressuring the Dutch government to force 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 its meeting of April 10-13, 1946, the case was put before the Commission and the delegates agreed to impress the gravity of the situation on their respective governments (Jaag 1956; Lillinger 1977). 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." (Jaag 1956) The Swiss government, itself worried about ailing salmon fisheries and increasing pollution in the Rhine-fed Swiss lakes, seized the occasion of an international fresh-water biology congress in Switzerland in 1948 to initiate a serious debate on Rhine pollution. At the first International Conference on Salmon Fisheries on the Rhine 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. (Lillinger 1977) The representatives of the member states resolved to agitate for such a commission and thanks to diplomatic initiatives by the Swiss government, it was established in the spring of 1948 with Switzerland, Germany, France, Luxemburg, and the Netherlands as members.

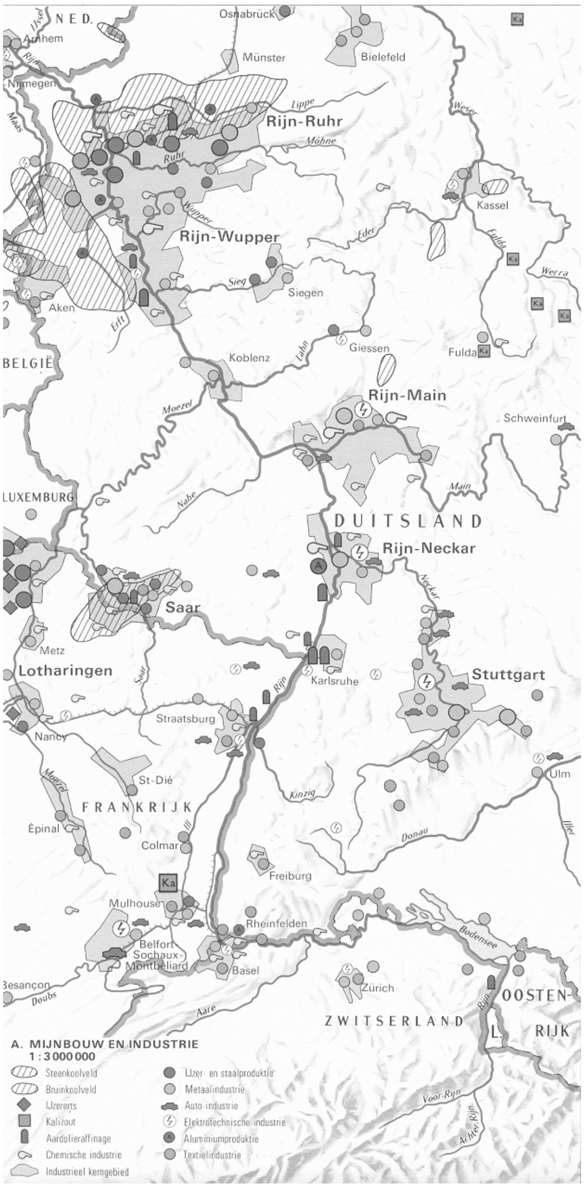

Figure 3: Rhine River from Bodensee to Dutch border showing concentrations of mining and industry. Source: (Wolters-Noordhoff 2003).

Though it took until July 11, 1950, before the "International Commission for the Protection of the Rhine against Pollution" (ICPR) actually met – again at Basel, time had not been wasted. In short order and by unanimous consent a technical subcommittee charged with investigating patterns of pollution on the river was set up. 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" (Jaag 1956). In his retrospective account, the biologist Jaag noted that the subcommittee's first order of business was to establish standard, uniform and enforceable protocols for the measurements. This was important because the measurements would only be coordinated and not actually carried out by the subcommittee. This was left to the appropriate technical agencies in the riparian states themselves. Almost three years later, in May 1953, a second meeting of the commission authorized the subcommittee's hard-won proposal for a common measurement protocol and a month later officials at nine locations along the Rhine from Bodensee to Vreeswijk were able to initiate the first truly international measurements of Rhine pollution. Assays of physical and chemical composition were taken every two weeks at different depths and positions across the axis of the river. (Isebree-Moens 1956) Locations along the river were chosen so as to be able to deduce which stretches of the river (and which discrete 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 subcommittee concluded with some alarm that: "In those stretches examined by the committee, and especially in its lower reaches, the Rhine is so heavily burdened that all means must be mobilized in order to effect improvement in the situation as quickly as possible" cited in (Isebree-Moens 1956) .

However, the Commission was utterly powerless in the face of the mighty 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, until 1953, a secretariat. In spite of this it had been able to clear enough diplomatic space to be allowed to garner compelling quantitative evidence for the Rhine's sorry state. Coupled to pre-war Dutch measurements the new data presented a picture of continuing degeneration in water quality on all fronts.

Meanwhile, back in the Netherlands, the riverine waterworks, led by Amsterdam and Rotterdam, had organized 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 organization to ensure that the specific interests of downstream Rhine waterworks remained visible in the diplomacy on Rhine pollution. In 1958, Amsterdam finally commissioned the pipeline which began to feed Rhine water into its dune water system. It is probably not coincidental that 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 as it entered the country at Lobith. Although given the prevailing governance arrangements for the Rhine, there was no hope of achieving these demands in the short term, the interests and attitudes of the middle riparian states were nonetheless slowly changing. As in the Netherlands in an earlier phase, the political agency of municipal waterworks (sometimes allied with nascent environmentalist groups) played a prominent role in raising consciousness about pollution and cajoling governments to take action. In 1950, directors of Swiss and German waterworks around the Bodensee first 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 combined in the Arbeitsgemeinschaft Wasserwerke Bodensee-Rhein (AWBR) in 1968. Like the Dutch RIWA, this branch organization carried out its own (stringent) assessments of water quality and was in general active in bringing the importance of clean water to the attention of politicians and the public. Ten years earlier, in 1958, Swiss and German waterworks on the upper and middle Rhine had joined forces in the Arbeitsgemeinschaft Rhein Wasserwerke (AWR) again an organization 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 from Rhine pollution) 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 (Veen 1969) 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 (Dieperink 1997).

The citation heading this article, by the chief biologist of the Amsterdam Public Health Service, Isebree-Moens, sounds rather defeatist. Yet hardly anyone spent more time and energy in fighting Rhine pollution both nationally and internationally than this woman. Her apparent fatalism must 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 agitating for new international riverine governance arrangements. The prudence of this realist standpoint of course depended entirely on trust in the technological capacity for purifying even the most disagreeable water into palatable drinking water. We have seen how both 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 classical 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 routine 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. cited in (Veen 1969)

These amorphous fears had antecedent roots 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 near Bingen Loch in June, 1969. If masses of fish could just up and die from one moment to the next, who was to say what kind 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 had ensured that the waterworks could be disconnected 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.[14] However, this did nothing to allay the chronic fear of undetectable "background toxins." This could only be laid to rest by measures at the sources of pollution, rather than at the waterworks.[15]

The Endosulfin incident and the fears it raised had two immediate effects. First, it heightened consciousness among Rhine waterworks that they all had a common interest in agitating 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 Internationale Arbeitsgemeinschaft der Wasserwerke im Rheineinzugsgebiet (IAWR) in which the RIWA, the AWR and the AWBR combined forces. Through the annual Arbeitstagungen and lobbying and publicity, the IAWR enabled the 83 member Rhine waterworks to play the role of watchdog from a "left-wing" position in the international maneuverings 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:

… not before in the history of the Rhine was there 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 CD) (Veen 1969)

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 the "right moment" inasmuch as this was the takeoff period for a new heightened environmentalist consciousness which vastly increased the popular and political scope for regulating Rhine pollution. Throughout the 1970s national and regional governments built or helped subsidize the construction of numerous wastewater treatment plants. Even huge firms like BASF in Ludwigshafen invested huge amounts in new (and well-publicized) wastewater treatment plants. (Heinz 1977). And, very gradually, a number of indicators of pollution began to exhibit a declining trend for the first time in nearly 100 years of measurements. Although the Rhine waterworks were by no means yet in a position to relax their vigilance they could look with satisfaction on the emergence of a new environmentalist ideology and the entrance of new and politically militant players into the field of pollution regulation in the form of activist groups like Greenpeace or the Dutch group Reinwater. These new groups now began to form a new radical left-wing in the opposition to Rhine pollution, essentially demanding zero-pollution and beginning to incorporate all kinds of biological and ecological criteria into their demands which would become part of official policy after the big Sandoz fire in 1986. This provided the political space to envisage not only a cleanup, but the complete ecological restoration of the Rhine, embodied in the 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

What lessons can we draw from this story about urban waterworks and a river? In particular, what light might it shed on the general understanding of urban infrastructures in transition and problems of governance? A basic point is that urban infrastructure does not stop at the city limits, or at least does not long remain there. This means that the politics of urban infrastructures also tends to be more than merely urban politics – sometimes much more. Even in the late middle ages when the burghers of Amsterdam and Rotterdam could still dip a bucket into the Amstel or Rotte rivers to quench their thirst, the water came from out of town and it was of no little consequence what had happened to it on its way. The implementation of centralized water supplies in Europe in the 19th century was coeval with the rapid expansion of urban population and the emergence of a new water-hungry hygienic order. So from the start these new infrastructures were under continual pressure to expand – while maintaining both quality and low rates. The drama, such as it was, turned on finding an acceptable and sustainable solution for quantity, quality and cost. We saw that Amsterdam and Rotterdam adopted different initial strategies but that in the course of time, as demand increased to such an extent that regional water sources were no longer a dependable source of supply for Amsterdam, they converged on the Rhine.

Now the point of the paper is that the transition of Amsterdam's water system from dune and lake catchments to the Rhine river also entailed a radical change in the governance arenas in which it had to operate. Whereas exploiting regional sources of supply entailed only bilateral negotiations with other municipalities or provincial authorities, extracting water from the Rhine required a national and an international strategic vision. Nor was this simply a matter of voicing interests in the councils of already established governance arrangements, but rather of political entrepreneurship in search of new alliances and forms of leverage to constrain upstream polluters. This required an intermediate stage of national consolidation of Rhine waterworks interests in order to pressure the national government to agitate for new transnational governance arrangements. And, though the initiative had now passed to the nation states – and in part to the nascent European Community - success required continual pressure from the organized Rhine waterworks.

The complete story would of course also look at cities as (Janus-faced) sources of pollution as well as consumers of fresh water. The cleanup of the Rhine also entailed the development of new regimes of municipal wastewater treatment. Unburdening the waterworks, also meant burdening the sanitation department. And the account also has implications for environmental histories of river basins. The point here is that cities count, especially on heavily industrialized rivers like the Rhine, and that crucial transitions to new environmental governance arrangements in river basins may at certain stages of development depend heavily on the interests and political acuity of the managers of urban infrastructures.

Notes

1 Between 1870 and 1890 Amsterdam's population increased from 265,000 to 408,000, or by nearly 54%.

2 The measurements were taken at Amerongen on the Nederrijn. They included counts of suspended particles, assays of chloride and ammonia content, and the determination of the potassium permanganate index. Chlorine is a measure of what is commonly known as salinity. The two latter values established the degree of organic pollution. A similar set of measurements were taken in 1916 by the Government Institute for Public Water Supply.

3 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. Between 1932 and 1938 a second more modest series of measurements (which, however, now also included phosphates) were taken at a laboratory in Vreeswijk. See (Heymann 1931)

[4] 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.

[5] The "Maas" here should not be confused with the Meuse, which in Dutch is also called the Maas. The Maas in Rotterdam is by all accounts a branch of the Rhine.

[6] 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 an influential environmentalist group, the Dutch Society against Soil, Water and Air Pollution.

[7] 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. (Heymann 1931)

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

[9] This was an apposite metaphor, because the main attack came from the sea and could only be countered by extensive flushing of ditches and drainage canals – chiefly with "fresh" Rhine water. The saltier this got, the less effective the flushing became.

[10] The IJsselmeer was a large new freshwater lake formed by the closing off of the Zuiderzee with a sea-dike. The lake, officially 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 drinkwater 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.

[11] Van Royen is a bit tendentious here. A number of German cities, particularly along the upper and lower Rhine, did use Rhinewater, but only indirectly in the form of Uferfiltrat. 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 been the inspiration for Amsterdam's dune infiltration plan.

[12] Mark Cioc graphically describes the constructed division of labor between the rivers of the Westphalian mine district, with the Emscher, reduced to a concrete-lined canal, serving as collective sewer and the Ruhr being reserved for fresh water supplies (Cioc 2002). 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.

[13] Rijksinstituut voor de Zuivering van Afvalwater

[14] 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 singular dependence on the Rhine.

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

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