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# Power, pleasure, and pollution: Water use in pre-industrial Nuremberg and Prague[1]

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**Abstract:**
F. Ruhland: *Power, pleasure, and pollution: Water use in pre-industrial Nuremberg and Prague.* – Klaudyán, 4, No. 2, pp. 5–18. By looking at the uses of water in late medieval and early modern Nuremberg and Prague, the paper aims at contributing to the profile of pre-industrial cities in environmental history. After a brief overview of the role pre-industrial cities have played in environmental history and related fields, the paper discusses the relationship between water and city in the light of three issues: water as a source of power, water as a polluted resource, and piped water as a commodity. The first point is how water mills and riverside crafts were shaping the rivers in both cities. Secondly, the paper reviews cases of river water pollution in both cities and places them in a contemporary context. Thirdly, the paper looks at the development of technical systems of water supply consisting of water works, water towers, conduits, a few public fountains and dozens of private taps. Apart from being physical networks, these infrastructures networked consumers of running water in a sometimes conflicting way. The paper argues that the provision of piped water turned water into a commodity even before the 19th century. Finally, social and spatial inequalities in access to running water in both cities are discussed.

**Key words:**
urban environmental history – urban water supply – water pollution – infrastructure – public/private access to water – pre-industrial Nuremberg and Prague

## 1. Introduction: A view back from the 19th century

Urban historians demonstrated persuasively, how the implementation of technical networks contributed to the conquest of the urban crisis in the 19th century. However, it still is a well established assumption in historiography that pre-industrial european cities were being swallowed up by mud and that they were sinking into filth during the late Middle Ages and early modern times. Joel Tarr and Gabriel Dupuy stated: "Although technology and cities have always been interdependent, only since the advent of industrialism in the 19th century have urban technological networks evolved" (Tarr/Dupuy, p. XIII). Agreeing to the statement in general one must add that it is hardly appropriate for the case of urban water supply. With regard to the durability of pre-industrial cities it may be supposed that networks of urban water supply created – metaphorically speaking – "urban islands of cleanliness" and that their investigation may deliver insights into the relative stability or vulnerability of pre-industrial urban societies.

Both infrastructures built in ancient cities and infrastructures established in industrialized cities since the second half of the 19th century – being "prime characteristics of the modern city" (Melosi 2003, p. 195) – have attracted historians' attention. But the infrastructures of water supply in medieval and early modern cities were almost neglected or they were accused of notorious inefficiency. Urban water supply still is predominantly an issue of history of technology,[2] which may be rooted in the admiration for centralized water supply systems built in antiquity and since the 19th century, as the history of water technology was (and to some extent still is) pursued first of all by engineers. By comparison the small-scaled and decentral structures of the Middle Ages and early modern times can give the impression of having been ineffective.

## 2. Rewriting urban environmental history

The predominance of studies dealing with industrialized (modern) cities is vast. In many cases, the history of urban environments is written as if it could be reduced to a history of environmental problems or to a history of pollution (Bernhardt 2001; Dirlmeier 1981b; Simson 1978). Crisis "produced" most written historical sources that are relevant to environmental history and crisis is an important element in the relation between urban populations and their environments, but this relationship is multi-layered and contains "destructive" elements as well as "constructive" facets. The *courte durée* of more or less short-term environmental problems has to be embedded in the *longue durée* of anthropogenic changes transforming the urban sphere.

Even in latest studies, the image of environmental conditions in pre-industrial European cities is marked by the assumption of a "permanent crisis of hygiene", partly caused by the lack of safe and sound drinking water (Radkau 2000, p. 174). This view is based on a long lasting tradition that roots deep in the 19th century. Regional as well as general historiography provides loads of drastic accounts about cities overflowing with dirt against which insufficient and primitive measures were taken (Reicke 1896, p. 290; Strell 1913; Smith 1976; Meurer 2000). But this image seems to be distorted. In the early 1980s, historians Günter Bayerl (1980) and Ulf Dirlmeier (1981a) started off a reconsideration in german historiography.[3] They pointed out that normative written sources, first of all statutes, which are quoted most frequently just reflect an authoritative view of the environmental conditions in pre-industrial cities. Further types of sources should contribute to a well-balanced assessment. Roberta Magnusson (2001, p. 161) recently added the explanation that the "frequent practice of reissuing statutes related to water supplies and urban sanitation may not indicate the failure of such laws", but the continuous need to teach generations of rural immigrants the proper way of urban water usage.

## 3. Defintion and approach

The essay in hand is orientated by the approach of urban environmental history that can be defined as "the story of how man-built or anthropogenic structures (*built environment*) and technologies shape and alter the natural environment of the urban site with consequent feedback to the city itself and its population" (cit. in Melosi 1993, p. 2). Whereas this definition rests on the experience of modern cities, it can be applied to pre-industrial conditions very well. The definition offers the advantage of stressing the *longue durée* of urban environmental changes. Within this research context, water seems to be the most applicable theme when transferred to pre-industrial times, for the relation between water and urban populations has produced plenty of historical sources.

The research contains of:
a) the framework: anthropogenic changes of urban hydrology, pollution of water resources by *pollution microbienne* (microbial pollution from households) and by *pollution artisanale* (industrial pollution from crafts and trades) (Mieck 1990);
b) the core: development of the spatial organisation of the infrastructure of water supply and its relations to topographic, demographic, economic, social and symbolic structures of urban space. The physical outcome of the changing approaches towards using water as a resource are different

types of infastructures and technical systems of water supply. Coming back to the above mentioned definition of urban environmental history, infrastructure made up a part of the built environment and it had –once built – extensive and long lasting effects on the relation between urban societies and their environment.

## 4. Water and urban societies: Historical hydrologies

The classic example illustrating the interdependence of urban societies and water is Venice (Bevilacqua 1995). However, one might state slightly exaggerating that each and every pre-industrial city was linked with water as directly as Venice. Water was the essential resource, for drinking and industrial water supply as well as for energy generation, but high waters constantly threatened urban settlements. In order to serve the purpose of defence, of households, of water mills, of baths, of crafts and of other water users, rivers and brooks were diverted and canalized (Krings 1994). Whole nets of little canals run through a lot of towns in southern Germany (Kleemaier 1985; Herbst 1992, pp. 12–72) as well as in northern France (Guillerme 1988; Lohrmann 1988), where urban canals and brooks reached lenghts up to 11,5 km – getting king Louis IX. to call Amiens "little Venice" which was not exaggerated: „Venice was not just an image, it was a tangible reality in many of the cities of the Middle Ages" (Guillerme 1988, p. 75). The second topic related to water in the urban sphere represents the whole complex of water pollution and sewerage which is warped by a lot of prejudices still associated with the "Dark Ages" (Illi 1987, pp. 9–72). The third major topic is the infrastructure of water supply in the narrower sense: ground water wells, waterworks, conduits and fountains, their use and their connections with material and nonmaterial structures of urban space.

Without doubt, water is just *one* compartment of the urban environment and has multiple links to the other compartments climate, relief and soil, and flora and fauna. That is why it would be extremely helpful to establish general concepts that are able to integrate the single divisions. The ecosystem approach might be useful.[4] At least, thinking of the city as an ecosystem overcomes the idea of a firmly established dichotomy between the pre-industrial urban settlement and the countryside and reminds one of the city's open character (Hughes 1998, p. 110): "The city cannot be understood properly unless it is seen as an ecosystem, as a series of ecological relationships. It does not exist in isolation, but interacts with other ecosystems and functions as part of a larger ecosystem. A study of the city, therefore, must see human social factors as operating within a complex series of ecological processes that impact and affect them." Among further concepts that might be helpful just three should be mentioned: the urban metabolism combined with "the bundling of energy" (Irsigler 1991), the ecological footprint of cities combined with its specific traces in the cultural landscape of the urban hinterland,[5] and the concept of urban vulnerability (Pawson 2002).

## 5. The cases of Nuremberg and Prague

The considered period of time strechtes from the end of the Middle Ages (15$^{th}$ century) to the second half of the 19$^{th}$ century. Comparing Nuremberg with Prague, two of the capital cities in Central Europe during the late Middle Ages and early modern times, may help to gain an insight into the historical development of the relation between urban societies and water resources. The source material used in this study is quite heterogeneous, it comes from various contexts and dates from a period of almost 500 years. Four main groups of evidence can be distinguished: written records, cartographic sources, archaeological findings, and (little) surviving physical evidence. Written sources include narrative texts, chronicles, legislative texts (statutes, decrees), but as the early modern times went on more and more files and books were produced for administrative tasks concerning water (e.g. citizens' petitions and reactions of the authorities). Much more of these types of sources have been preserved in the municipal archives of Nuremberg than in Prague. Files were sometimes accompanied by maps and plans. Urban cartography became established at a high level in both cities in the late 16$^{th}$ century and is an extremely important source. Archaeological evidence and physical survivors such as wells, fountains, troughs, conduits, water towers, and anthropogenic manipulations of the physical environment in general can answer critical questions. In this case, Prague has incomparably more to offer than Nuremberg.

## 6. Along the rivers of Nuremberg

The river Pegnitz was intensively used by water mills and crafts in Nuremberg and its surroundings from the Middle Ages until the 19th century. Old maps reveal that mills and crafts had lent the Pegnitz its character, whereas the small tributary Fischbach had become a completely artificial channel in order to serve as a water and energy resource (Centrum Industriekultur Nürnberg 1986). A cartographic source of inestimable value in this context is the *Pfinzing-Atlas* from 1594.[6] This monumental work of cartography contains, among other maps, several plans of the rivers Pegnitz and Fischbach that show the topography of crafts and other water-using facilities like baths situated along the riverbanks.

In the suburban environs of Nuremberg, the Fischbach had been diverted from its original bed and its water level was regulated by several weirs which triggered off conflicts between craftsmen depending on water supply on the upper course and those on the lower course of the Fischbach. Inside the city walls of Nuremberg, the Fischbach was forced into an artificial bed made of solid stone. A combined analysis of cartographic and different written sources makes it possible to create a istorical topography of water use and water pollution.[7] As for water pollution, two "hot spots" may be identified along the Fischbach. In the southern suburban surroundings outside the city walls of uremberg, the almost monostructural dominance of textile crafts attracts attention. Bleaching, dying and washing textiles as components of the manufacturing process used and polluted the water of he ischbach.[8] Inside the city of Nuremberg, tanneries were responsible for major emissions.[9] Taking into account the load from water polluting crafts outside and inside the city (i.e. pollution artisanale) and adding the potential emissions from households (i.e. pollution microbienne), the water quality of he Fischbach was presumably an unpleasant everyday experience. But there is no question that the unicipal authorities were concerned about the state of the Fischbach. Municipal master builder Endres Tucher employed three employees who specialized in maintaining the Fischbach. In the second half of the 15th century, Tucher issued a detailed package of measures for the maintenance for which those citizens living near the Fischbach were obliged to pay for (Lexer 1862, pp. 221–239). In addition, decrees issued by the municipal council, the first dating from the early 14th century, were designed to protect the water against pollution by restricting crafts and certain activities to specific zones along the Fischbach (Schultheiß .1965, p. 62, 146, 235; Lehnert 1981). Lavatories were not permitted at a distance less than 3 metres, tanneries and their emissions were limited to a particular section in the tanners' quarter on the lower course of the Fischbach (Lederergasse). Though, it is not allowed to infer the "real" water quality from the text of these decrees, because we do not know whether they were reactions to tangible problems or just prophylactic measures (Dirlmeier 1981a, p. 145).

The density of different sites of water usage created a potentially explosive situation along the much bigger river Pegnitz as well. The whole course of the river in the Nuremberg area was occupied by water mills. If one was walking along the banks of the river inside the city walls from the east to the west (along a 1,2 km stretch) at the end of the 16th century, one would have been able to detect six major mill complexes and no fewer than 48 water wheels.[10]

## 7. Paper mills: The classic case of water pollution

The situation is highlighted by the conflict between water polluting paper mills and other water users – the "archetype" of pre-industrial pollution (Bayerl 1981). In 1591, a prominent case was sparked off by a new paper mill that was to be start running in the village of Mögeldorf, located on the river Pegnitz to the east of Nuremberg (Bayerl 1989, pp. 75–78). As a lot of water was involved in the production process of the paper made of old rags, the effluent emitted to the river called local villagers into action. They argued that the paper mill's effluent would poison the cattle which used to be watered in the river, that it would poison those fields irrigated by river water and that it would threaten the health of the villagers. Local owners of public baths and fishermen supported that view. The paper miller defended his project by pointing out to the environmental harmlessness of existing paper mills, to the self-purification of rivers and to the permission issued by the municipal council.

The council itself made a compromise on the divergent interests by giving the paper miller permission to run the mill and by making it a condition for the paper mill to drain off the waste water all around the village of Mögeldorf. This conflict is a clue of the mechanism of environmental conflict management in pre-industrial times; but is the Mögeldorf case representative of other regions as well and what does it say about the quality of river water in pre-industrial times in general?

## 8. The river Vltava in Prague: Pollution in context

Compared to the much smaller river Pegnitz, the bigger river Vltava (Moldau) in Prague was less intensively marked by mills and crafts, although dozens of them were situated on the banks and on river islands (Podzimek 1976; Semotanová 1995). Clusters of mills forming groups round the single weirs were significant of the situation in Prague. But unlike today the riverbanks were not reinforced, as the huge quaysides were not erected before the 1840s (Kohout/Vančura 1986).[11]

Like in Nuremberg, we have early records of river water pollution and its perception by citizens in Prague. Jan Bechyňka, a hussite priest from the New City of Prague, mentions the polluted river water of the Vltava in his pamphlet *Praga mistica*, written between 1503 and 1507 (Bechyňka 1984, p. 38).[12] His observation might be right without a doubt, but one has to be careful considering Bechyňka's religious and political background, as he was not only an anti-papal theologian, but also an mystic who recognized the physical and social environment of his contemporary Prague as full of allegories related to religious topics. Bechyňka saw the river water of the Vltava in a dubious light, as the Vltava has its source in the south, the direction of Rome and the pope. In Bechyňka's eyes, pollution could infect the river water just like sins could "infect" the society (Bechyňka 1984, p. 38).

This is to point out that the perception of the urban environment is mirrored and broken by ideologies, theories, models and metaphors on the one hand and by positive or negative views and connotations of certain features of the urban environment on the other hand. Attitudes towards the urban environment are located deliberately or unconsciously across a wide spectrum of thought between the extremes of total disapproval of the city on the one hand and of emphatic sympathy for the city on the other hand. Pro-urban approaches occured in medieval and early modern times and were established and institutionalized as a characteristic literary genre, *laudes urbium*, which has its roots in classical antiquity and was "rediscovered" by humanist scholarship. Opposing anti-urban approaches of pre-industrial times culminated in the polemic of physician Christoph Wilhelm Hufeland (1762–1836) in his famous book *The Art of Prolonging Human Life* (first published in 1796). He describes cities as "open graves of mankind" refering to increased mortality in bigger cities[13] compared with smaller towns and the country (Hufeland 1798, p. 29 f.)

Written evidence regarding river water quality and pollution in pre-industrial cities is contradictory and biased. We are confronted with overlapping superstition and emerging scientific approaches. In his *Oeconomische Encyklopädie*, a multivolume encyclopaedia containing the scientific and technological knowledge of the late 18th century, Johann Georg Krünitz (1787, p. 59 f.) informs us of the analysis of brewing water in great detail, but at the same time he states that "sometimes the best beer is made from the worst water." It seems very likely that river water was less polluted in pre-industrial times than it is assumed in general.[14] A tool suitable for calibrating the contradictory written sources might be the creation of a quantitative index for each city following the *Water Pollution Index* that was recently constructed from determinands such as abstraction, population, precipitation, production, sewer treatment and agriculture for the Mersey Basin in England (Burton, Howard, Goodall 2003).

## 9. Water supply in Nuremberg

The view on the urban scene is not purely materialistic, but takes into account that infrastructures are just a part of urban technical systems. The term *infrastructures of water supply* underlines the role of technology and it refers to the main components as waterworks, water towers, counduits, fountains and so on. It may be more appropriate to use the term *technical systems of water supply*, which places particular emphasis on the key role of people within these systems: decision-makers that implemented technologies on the one hand, water consumers on the other hand

(Melosi 1990). It takes into account the role of individual urban inhabitants and groups, different types of social organisations and symbolic connotations.

Elaborated infrastructures for water supply developed in Nuremberg since the late Middle Ages (Fischer 1912; Lehnert 1966; Hirner 1986). Private (not accessible to the public) and public (accessible to the public) ground water wells ensured most of the supply. An examination carried out in 1810 has listed 138 public and 1049 private wells, a relation that is characteristic for the whole pre-industrial era. The books of municipal master builders (edited in Lexer 1862; Mummenhoff 1880; Stromer 1984) as well as the more specialized records in the books of pipes and the books of wells offer excellent insights into the built environment of pre-industrial Nuremberg.[15] These records show that the municipal building authority under the direction of the master builder had the main influence among the actors shaping the built environment in pre-industrial Nuremberg. Anthony Sutcliffe's (1982, p. 107) statement that, until 1800, "even in the largest towns, manipulation of the environment was conceded almost entirely to the free play of the market" is not transferable to the situation in Central European cities like Nuremberg or Prague, where the building authorities controlled the development of the built environment to a great extent.

Public wells were maintained and financed by cooperatives of citizens (Schmid 1998; Simon-Muscheid 2001). These cooperatives formed groups of residents round every single well and could be described as human networks. It can be ascertained that 30 to 100 households paid mandatory levies for the maintenance of a public well.[16] These human networks may have affected the urban society like technical networks had an effect on the shape of the physical environment. One might ask the question whether wells and cooperatives contributed towards creating a certain identification of citizens with their neighbourhood and with their quarters (Jütte 1991), for example by means of having celebrations around the wells.

## 10. Piped water in Nuremberg: The making of a commodity

Several wooden gravity flow pipes provided public fountains and private taps since the late Middle Ages with spring water. In 1584, the first waterworks, the *Blausternwerk*, started to pump well water through conduits into 67 fountains, among them one important public fountain, seven taps in public buildings and 59 private taps. The main pipe had a length of 2350 metres. Two smaller waterworks, *Almosmühlwerk* and *Nägeleinswerk*, were installed into existing water mills in c. 1620 and 1687.

According to a mapping survey conducted in 1811, a plan of the network of conduits in the early 19th century was drawn, which shows the legacy of pre-industrial water supply in Nuremberg. The plan shows networks consisting of 3800 metres of pipes made of lead and 8 600 metres of wooden pipes. Such wooden pipes put a steady strain on the city's supply of timber and it is obvious, why the municipal council was anxious to replace the wooden pipes by pipes made of lead. Several special decrees on this issue exist in the archives that spotlight the connection of two important branches of the urban metabolism, water and wood.[17]

Although the numbers of by far less than hundred private households which were consuming running water from private taps seem marginal from a modern point of view, the connecting character of the networks sowed new seeds of conflict between the connected consumers with which the municipal bureaucracy had to deal. Each user of running water kept an eye on the water consumption of his fellow users, for the system worked in such a way that a surplus of water in the taps of the other consumers could bring about a shortage of water in the own tap.[18] In order to control the amount of emitted water, calibrations of the private taps and of the waterworks took place at irregular intervals.[19] Calibrations were costly actions which involved several municipal institutions and servants. Decisions on running water were made under the authority of the city council by the municipal building authorities and by a special *standing committee on the spurting waters* (Deputation zu den Springenden Wassern). As far as the protocols and descriptions of the water calibrations are preserved, they highlight quantitative aspects of water consumption. The most intriguing finding that appears in all protocols is the quite remarkable surplus of water that was delivered into the houses. In 1739, the 52 water users connected to the network of the waterworks

Blausternwerk were supposed to get a total of 103 Eimer ("buckets") and 16 Viertel ("quarters") per hour,[20] but a total consumption of 128 Eimer and 25 Viertel was discovered during the calibration. As a result of the calibration the output was adjusted to be 108 Eimer 12 Viertel in future.[21] The calibrations of the waterworks Nägeleinswerk produced even more extreme results, for example in 1766: the 54 participants were supposed to be supplied with a total of 68 Eimer, they received 150 Eimer 20 Viertel in fact and their consumption was adjusted to be 73 Eimer 18 Viertel in future.[22] It was not unusual that a water consumer received double the amount of piped water which he was supposed to get and pay for: instead of receiving for example 2 Eimer per hour (c. 2,46 litres per minute) he would get 4 Eimer 16 Viertel per hour (c. 5,53 litres per minute). These quantities demonstrate that pre-industrial water supply was interfering in the water resources usually in a modest way. The social implications are more relevant to this context.

Consumers of running water belonged to the upper class of the Nuremberg society. The amenities and luxury of being supplied with 150 litres of water per hour (2,5 litres per minute) *in* the household can only be estimated properly when compared to the labour which was caused by drawing water in buckets from public fountains or wells – an everyday experience for women and maidservants. Piped water was an expensive and prestigious luxury. Those citizens who could afford to be connected had to petition the municipal authorities for a private tap or for an increase of water after being connected. Another possibility was to purchase the permit to use running water of an citizen who had died or did not need it anymore.[23] The supply with running water transformed the perception of water and its actual availability from being a public resource drawn from public wells and fountains to being a partially private commodity which was measurable, controllable, adjustable, purchasable and deprivable. Being connected to a conduit and having a private tap meant to be in a very privileged position, at the same time it meant to obey new social conventions and to maintain discipline which differed from previous relations between city dwellers and water. The council of Nuremberg felt bound to emphasize the priority purpose of this network several times: the purpose was described as "the embellishment of public space" in contrast to "the pleasure of private tap owners and water consumers" (Fischer 1912, p. 10). These statements refer to the tension between public and private interests and their mutual legitimation in urban societies.[24] The infrastructure's essential purpose, so the argument went in Nuremberg as well as in Prague, was meant to supply public fountains (however few they were), not private taps.

## 11. Water supply in Prague

The age of waterworks in Prague started in the second half of the 15th century (Klíma 1909; Pavlanský 1928; Kurka 1976; Jásek 1997). Four central riverine waterworks were consecutively built in the Old City (before 1427), the Upper (c. 1490) and the Lower New City (before 1484) and on the Small Side (before 1537). These waterworks pumped unfiltered river water to the water towers from which it run through conduits to hundreds of fountains and taps in the cities. Whereas pre-industrial water supply has left hardly any traces in Nuremberg (except for monumental fountains!), the four water towers of the former waterworks still are impressing landmarks along the banks of the Vltava (Jásek/Beneš 2000). The rich architecture of these water towers reminds of their former importance. Being prestigious showpieces these waterworks were integral parts of city guides and topographical descriptions and probably attracted visitors, as did the waterworks of Augsburg which amazed Michel de Montaigne when he visited the city in 1580 (Stilett 2002, p. 78).

Pre-industrial infrastructure was not as static as one might think, it was made up of a large number of major and minor transformations both in terms of quantity and quality. But, although most of these transformations are clear in technical respect, we often can only speculate on environmental and socioeconomic consequences and on the perception of such transformations by individuals and groups in the urban society. Once again, it is Jan Bechyňka in his text *Praga mistica* who gives an account of the introduction of river waterworks in Prague in the years before 1500. Bechyňka criticizes the new technology of waterworks because of its high costs which must be borne by the citizens in form of increased water charges (Bechyňka 1984, p. 38; Rejchrtová 1984, p. 12).

## 12. Networks of water supply in Prague: The spatial dimension of inequality

The examination of large scale plans dating from the 17th and 18th century contributes to get an idea of the spatial dimensions of water supply. These plans show the four networks of pipes which were connected to each of the four water towers mentioned above. Each network was independent and supplied one of the historical cities of Prague. Only the very extensive New City was supplied by two independent networks that could be connected in case of fire. A plan drawn in the mid-17th century shows a network of three main pipes in the Old City, to which 96 fountains were connected, among these were 12 public fountains, 11 taps in breweries and 13 taps in monasteries.[25] The ratio of private and public fountains was 7,4 to 1 which corresponds to the situation in Nuremberg, but it represents a higher proportion of private consumers than in other cities.[26]

A later plan of the Old City of Prague, dating from 1729, shows five main conduits providing 108 fountains and wells.[27] The comparison of these plans proves, how the pre-industrial infrastructure of water supply could be extended and improved. This project required large scale mapping and planning and it would appear that the author of the latter plan, miller Josef Václav Veselý, drew this plan in order to lay the new pipes of the enlarged network (Vičar 1968). Both plans of the Old City agree in that the jewish quarter (Josephstadt, Josefov) in the northern part of the Old City was lacking in supplies of piped water, since it was only supplied by two fountains in the street and one fountain in a bathhouse.[28] In addition, financial accounts of the fees paid by citizens for piped water between 1640 and 1672 inform us that the Prague jews had to pay the exceptional amount of 46 groschen for three fountains per year, while the usual user was charged only 4 groschen for one fountain per year.[29] Analysing the names of the water consumers in these financial accounts it follows that, like in Nuremberg, running water was an exclusive access to water resources which the urban aristocracy and upper class citizens could afford. A high proportion of ecclesiastical institutions and breweries supplied with piped water is conspicuous, and accords with the situation in other cities (Bayerl 1980, p. 196), but not with post-Reformation Nuremberg.

The plans depicting the courses of the conduits indicate spatial inequalities between areas densely supplied with piped water and areas completely excluded from piped water which could refer to economic structures and to social topography. Unequally distributed supply of piped water was the case in both cities: The northern and the southeastern half of Nuremberg was equipped with a very dense infrastructure, whereas the southwestern part was provided to a far lesser extent. In Prague, the Jewish Town as well as the eastern and southern parts of the Upper New City almost lacked for conduits. These results could refer to cases of *environmental inequity* or *inequality*, terms well established for industrialized cities.[30] Further research is necessary, for we know too few details about the social topography in pre-industrial cities (Denecke 1988). Conventional generalizations postulate a wealthy core surrounded by an area in which the status diminished outwards and assume spatially segregated quarters for social, religious and ethnic minority groups. But residential structures were much messier in reality: Segregated areas in which one social status group or one professional group (with the exception of tanners' quarters) dominated as well as ghettos like the jewish quarter in Prague were exceptional features of urban space. Since generalized assumptions of social topography are too inaccurate to be linked with the spatial analysis of water use (Langton 1979; Haverkamp 2002), in-depth inquiries into the inequalities of water supply require to gather knowledge about the dwellers who lived in each and every house within a very long period of time. In summary it may be said that the use of running water was a privilege of the highest social strata and certain craftsmen and municipal institutions, but ground water wells ensured the basic supply of city dwellers until the late 19th century.

## 13. Questions and conclusions

A major question for further research is how the technological knowledge was diffused between the cities by single experts or even networks of experts, and which factors fostered or restricted the innovation of new technologies in pre-industrial cities. As far as we can say today, there was no direct exchange of ideas concerning the “hydraulic machinery” between Nuremberg and Prague – in spite of close and intensive trade relations between both cities particularly in the late

Middle Ages (Schenk 1969). But it is known that the King of Denmark negotiated about taking over the municipal employee responsible for waterworks and pipes, the master of water pipes (Röhrenmeister), from Nuremberg in 1613. On the other hand, Nuremberg was interested in "spying out" the water supply of other cities, when two masters of water pipes were sent on a several weeks' holiday trip in order to visit waterworks in several cities in 1618 (Fischer 1912, p. 121).

An elaborated compound of different technologies is characteristic for pre-industrial water supply in Nuremberg and Prague. Pre-industrial conduits meant the first step towards a centralization of water supply, in Prague even more than in Nuremberg. These pre-industrial systems can be understood as "proto systems", a term used by Martin Melosi (2000, p. 13) for early infrastructure in North America. The profound investigation of pre-industrial urban water supply reveals that the infrastructure was transformed in several ways even before the deep modernization started off from mid-nineteenth century onwards. The gap between pre-modern and modern infrastructures has to be put into a longer perspective. An extended time frame will show that transition and transformation of urban infrastructures are rather rule than exception. As a first step, the results of case studies should be integrated in typifications of pre-industrial infrastructures of urban water supply. In a second step, one might be able to determine whether and how the presence or absence of certain types of older technical systems had implications for the course of the discussion about the improvement of water supply systems in the 19th century. One should not work on the assumption that premodern water supply did not serve its purposes – at least as the contemporary city dwellers saw it. But the urban environment changed dramatically in the course of the 19th century. In view of industrialization, population explosion, increasing water pollution, new hygienic findings, and growing domestic demand for running water, the pre-industrial relation between water and city dwellers was on the brink of collapse: „The use of untreated river water (...) placed consumers at increased risk of exposure to waterbourne diseases, a problem that became more acute with the rapid growth of urban populations and the intensification of industrial pollution during the Industrial Revolution" (Magnusson 2001, p. 172). But the development of new technical systems since the second half of the 19th century did not render older infrastructures superfluous from one moment to the next. On the contrary, pre-industrial infastructure went through further stages of modernization until the early 20th century.

The current systems of urban water supply that have been installed as reactions upon the problems in the 19th and early 20th century show strong signs of crisis. Present politics cling to covering water consumption of cities through water resources supplied from remote and peripheral agrarian regions. These long distance infrastructures have caused ecological damages and are far from being sustainable. It would be naive to propagate the self-sufficient water supply of pre-industrial cities as an alternative or as desirable. But some of its elements and key characteristics may be worth reconsidering and could contribute to a new role model and culture of urban water use which has to be invented (Ipsen/Cichorowski/Schramm 1998; Schramm 2000). Historical investigations of environmental conditions in pre-industrial cities make it possible to extend the observation of environmental factors, but they don't allow us to make the diagnosis that the development of urban environments is one linear success story, inevitably changing for the better.

**Notes**

[1)] This paper was completed in September 2004. Financial support was provided by the German Academic Exchange Service (DAAD). The paper summarizes thoughts which came up during the initial stages of my ongoing doctoral thesis *The hydraulic Ancien Regime. A historical geography of pre-modern water use in Nuremberg and Prague.* My current research is funded by the Zeit-Stiftung.

[2)] For exceptions to the rule see Kluge/Schramm (1988) and Goubert (1989), but the bulk of literature focusses on technological aspects, such as Ehlers (1936), Grewe (2000) and Hoffmann (2000) for pre-industrial times. Some instructive urban histories of pre-industrial water supply have been written, among which, for example, Moeck-Schlömer (1998) on Hamburg and Jenner (2000) and Keene (2001) on London go well beyond local interests.

[3)] A few years later Hilger (1984) and Schneidmüller (1989) followed up.

[4)] The german standard textbook on urban ecology edited by two biologists points out that urban ecology has to consider the historical dimension, but the concept of a distinct historical urban ecology continues to be colourless (Brande 1998). See also Melosi (2003).

[5)] Richard Hoffmann gave a lecture about the ecological footprint of pre-industrial cities at the 2nd International Conference of the European Society for Environmental History in Prague in 2003 and prepares an article on this topic. The footprint of cities is suitable for historical investigations because a lot of traces can be discovered in the landscape as well as in cartographic sources. For Nuremberg see the chapter *Historische Kulturlandschaft der Reichsstadt Nürnberg* in Friedel/Frieser (1999, pp. 283–356).

[6)] Using the Pfinzing-Atlas has been made much easier by means of its excellent reproduction as a facsimile edition in Stadtarchiv Nürnberg/Altnürnberger Landschaft (1994). On this famous masterpiece of urban cartography and its author, Paul Pfinzing Sr, see Fleischmann (1994).

[7)] The basis for this topography form several early modern maps, e.g. in the Pfinzing-Atlas (Stadtarchiv Nürnberg/Altnürnberger Landschaft 1994, p. 15, 19), and an detailed account in the book of master builder Endres Tucher from the second half of the 15th century (Lexer 1862, pp. 224–229).

[8)] On the textile production in the southern suburbs of Nuremberg see Rusam (1979, pp. 50–64, 84–104).

[9)] A history of tanning in Nuremberg founded on archaeological evidence is provided by Lorenz (1999). On the topography of tanners' quarters in medieval towns in general see Cramer (1981).

[10)] According to the plan of the river Pegnitz (1592) included in the Pfinzing-Atlas (Stadtarchiv Nürnberg/Altnürnberger Landschaft 1994, p. 27). This plan was copied and continued by several later plans, for instance by a plan from 1601 showing Nuremberg and its hinterland and recording 12 mill complexes and 131 water wheels (Centrum Industriekultur Nürnberg 1986, p. 33 f.).

[11)] Pictorial and cartographic sources which inform about the development of the inner-city course of the river Vltava include the views and plans by Michael Peterle and Jan Kozel (1562), by Philipp van den Bossche (Sadeler-Prospekt, 1606), by Josef D. Huber (1769) and by Joseph Jüttner (1816) (Hlavsa/Mráz 1984).

[12)] On Bechyňka's biography and his writings see Rejchrtová (1984).

[13)] Hufeland mentions Vienna, Berlin, Paris, London, and Amsterdam.

[14)] This view is explicitely taken in Guillerme (1988, p. 97 f.) who stresses the “purgative effects” of some effluents emitted by crafts like tanners.

[15)] See for example Stadtarchiv Nürnberg B 35, Nr. B 1 (book of wells, 1419-59), Nr. B 1 a (book of pipes, 1501), B 1/I, Nr.7, Nr.8 (books of well water fees, 1479).

[16)] Stadtarchiv Nürnberg, B 1/I, Nr.7, Nr.8 (books of well water fees, 1479) and B 35, Nr. B 1.

[17] Astonishingly, the demand for timber for water pipes does not play a role in recent studies on urban wood supply (Radkau 1997).

[18] See e.g. Stadtarchiv Nürnberg B 1/II, Nr. LXXIIIb/34 (Jacob Muscat and Johann Wolfgang Keßler complain about water shortage and accuse Johann Caspar Wünsch of having too much running water, 1778), Stadtarchiv Nürnberg B 1/II, Nr. LXXIVa/11-14 (Johanna Magdalena Nürnbergerin and Georg Zacharias Plattner complain about water shortage and request a new water calibration, 1766).

[19] See e.g. Stadtarchiv Nürnberg B 1/II, Nr. LXXIIIb/33 (Water calibrations in the houses of Jacob Muscat, Johann Caspar Wünsch, Johan Wolfgang Keßler, Dr. Johann Gustav Silberad, Krochmann/Bedecker, Scherer and Barbara Maria Böheim, 1769).

[20] One Eimer (= 32 Viertel) was a liquid measure of about 73,7 litres.

[21] Stadtarchiv Nürnberg B 1/II, Nr. LXXIVa/94.

[22] Stadtarchiv Nürnberg B 1/II, Nr. LXXIVa/11-14.

[23] See Stadtarchiv Nürnberg B 1/II, Nr. LXXIIIb/35 (Georg Christof Drexel who had purchased two permits for half an Eimer each in 1765 applies for an additional Eimer of water, 1783).

[24] Furthermore they make empirical contributions to the discussion about the emergence of the public sphere contrasting with the representative publicness. To this day, this discussion rests on Jürgen Habermas's *The Structural Transformation of the Public Sphere* (first published in 1962). In the introduction Habermas (1991, p. 6) expressly states that "for common use there was public access to the fountain and market square – loci communes, loci publici."

[25] Státní oblastní archiv Třeboň, pobočka Jindřichův Hradec.

[26] The ratio of private and public fountains supplied by two networks in Augsburg was 2,7 to 1 and 3,7 to 1 in 1766 (Bayerl 1980, p. 195 f.).

[27] The original plan was destroyed. A copy exists in the Podnikový archiv Pražských vodáren.

[28] In the case of the Jewish Town, poor sanitary conditions were notorious until the late 19$^{th}$ century, when the "asanace" braught about radical measures of redevelopment and clearance ("finis ghetto") (Bečková 1993).

[29] Archiv hlavního města Prahy, sbírka rukopisů, rkp. č. 2159.

[30] Susan Cutter (1995, p. 112) defines environmental inequity as „a broad term that is used to describe the disproportionate effects of environmental degradation on people and places." Craig Colten (2002, p. 254) adds to the definition "circumstances that deny people and places environmental improvements" - sewerage, water supply and the like.

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