Water and City - Environmental History of Water and Sanitation Services in Tampere, Finland, 1835-1921

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Background

The city of Tampere is situated approximately 140 kilometers northwest of Helsinki, the capital of Finland. The city was established in 1779 along rapids between two lakes, Näsijärvi and Pyhäjärvi, with an elevation difference of 18 metres. The centre of the city is traversed by the nearly one kilometre long Tammerkoski Rapids around which the city and its industry originally grew up. The rapids, running from north to south, break an eskar formation separating the lakes. The eskar is one of the highest traverse ridges in the world formed during the Ice Age. Nowadays, Tampere is the largest inland city in the Nordic countries and the third largest city in Finland with a population of 200,000. This paper reviews the birth and early development of the City water and sewage works in Tampere (See Figure 1).

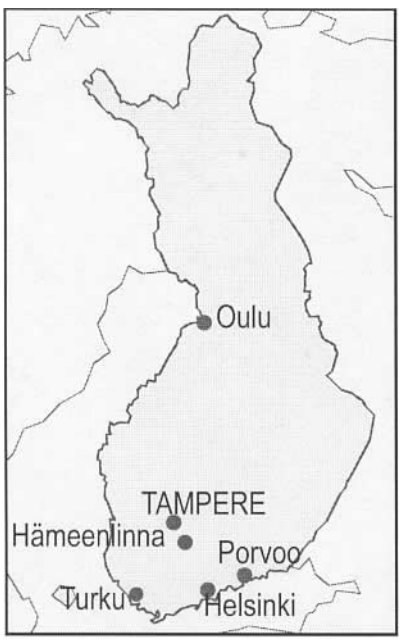

Figure 1. Location of the case city Tampere and some other Finnish cities

In many respects, this city represents the development of water supply and sanitation in the whole country. Tampere shows a case of somewhat problematic growth of a city at a time of emergence of the water issue, when traditional water sources, i.e. wells, were polluted and their yield was inadequate. Along with industrialisation the city grew rapidly. The systems were established in Tampere quite early compared to other parts of Finland and were also extraordinary in some respects. As a big industrial city on the Nordic scale, Tampere also influenced the choices of other cities trying to solve their water problems.

At first, the objective was to ensure the supply of fire-fighting water, then meeting the demand for domestic water supply. Thus, fires promoted indirectly the improvement of hygienic conditions along with sewerage systems. In spite of the incorrect scientific theory of miasma, the solutions made, however, advocated the right causes, i.e., improvement of the environment and safety of the city.

The first municipal "water pumping installation" in Tampere was founded in 1835.[1] The high-pressure facility was completed on 1898, but not on the scale of the original plan. Since slow sand filtration was rejected and

the outlets of the sewers were too close to intake pipes, the efficiency of the new facility was also its weakness: later typhoid fever spread fast over a wide area aided by the water pipe network. In 1916 the death of hundreds of people finally prompted the necessary decisions to be made. The threat of typhoid fever and other diseases spreading through water was removed in 1917 when chlorination of water was started. There have been no typhoid epidemics in Tampere since then.[2]

Research Questions

The research questions fall into two main categories. The first is concerned with the emergence of the water problem and its solution. In this study, the water issue refers to the crisis in urban water acquisition based on wells, which began to dry up and become contaminated due to inadequate or non-existent sewerage. Secondly, the water issue includes the aspirations of contemporaries for finding an answer to the question.

Contemporaries were searching for a solution to water acquisition for waterworks, and for drainage and environmental pollution from sewerage. Thus, water supply and sewerage were seen as solutions to the water issue. Fires ravaging the wooden cities of Finland were also a central motivator. When contemporaries in the various Finnish cities spoke about these problems, they were commonly using the term "water question".[3] This problem of water supply was solved only after prolonged planning and transitional periods. The transition from the so-called bucket system - based on wells, carrying the bucket - to the protosystem and modern water supply was a demanding process for municipal administration: many decisions requiring special knowledge had to be made.

More concrete research questions are related to solving of the water issue. How the water issue became a social problem and how the view that something had to be done arose in municipal administration? It is essential to clarify central policy-level decisions connected to the principles and practices. This also includes central technological choices made. These choices were at times a cause for bewilderment and indecisiveness among municipal decision makers, especially when specialists had different views on the matter. Did this indecisiveness cause any problems for water supply and environment?

In the 1860s there were plans to organise water supply by private entrepreneurs in Tampere. How and why did Tampere, however, end up having municipal water supply? The question of pressure levels in the water network was also important: water flowed in Tampere for many years under low pressure, as also in Oulu (Figure 1). Health reasons and, for instance, the requirements of the fire protection, however, led to the laying of a high-pressure water pipe in 1898.

A water charge based on consumption was also established in 1898, but why? The measurement of consumption is not as self-evident as one might imagine: earlier water was charged for a flat rate in Tampere while in Oulu during the first periods of waterworks charge was collected according to the method the water was fetched.

It is interesting that Tampere initially chose to use surface water while many other cities such as Hanko, Hämeenlinna, Lahti, Turku and Viipuri (Vyborg) went for groundwater (Table 1). In some cities, the establishment of a waterworks was postponed far into the 20th century - in Savonlinna until 1951.[4]

Table 1. Years of establishing the first urban water, sewage and fire works in Finland, 1876 to 1917.

City	Water works(years)	WaterSource	Waste-water(year)	Professional fire-brigade	System classification
Helsinki	1876	river	1880	1861	Modern system
Viipuri	1892	groundwater	1873	1881	Modern system
TAMPERE	1882	LAKE	1894	1898	PROTOSYSTEM
TAMPERE	1898	LAKE			MODERN SYSTEM
Oulu	1902	river	1897	1919	Protosystem
Oulu	1927	river			Modern system
Turku	1903	groundwater	1896	1869	Modern system
Hanko	1909	groundwater	1906		Modern system
Lahti	1910	spring	1910	1911	Modern system

City	Water works(years)	WaterSource	Waste-water(year)	Professional fire-brigade	System classification
Hämeenlinna	1910	spring	1910	1911	Modern system
Jyväskylä	1910	groundwater	1911	1922	Modern system
Mikkeli	1911	groundwater	1911	1911	Modern system
Porvoo	1913	groundwater	1894	1905	Modern system
Kuopio	1914	lake	1906	1913	Protosystem
Sortavala	1914	lake	1907	1913	Protosystem
Vaasa	1915	groundwater	1915	1909	Modern system
Kotka	1916	river	1890	1898	Protosystem
Kokkola	1917	groundwater	1923	1921	Modern system

The next category of questions throws light upon the effects of the decisions made and their relationship to the environment. Was the answer to the water issue feasible and operational? How did the decisions made affect the environment? Were the solutions practical or did they cause problems for inhabitants and the environment? Was the well-being of people and the environment improved by different solutions like the establishment of waterworks?

The water supply and sewerage of the city is also essentially connected to industry, especially as it is related to wastewaters. Industry was also an important water user and partly connected to the city water system. When considering solutions for their water supply, contemporaries did not pay attention to the problems of industry, even if their influence was felt. The focus during the research period was on community wastewaters.

Many industrial plants had at an early stage established their own waterworks and sewerage systems. These industrial water questions are examined only briefly, because in the early days industrial water use was significantly different from that of the community. The main industrial water use was for hydropower, while process water and other uses came later. Solid waste management was touched upon wherever it was closely connected to sanitation and sewerage systems. One such area is the flush toilet (WC).

Finally, when was the water supply and sewerage system of Tampere in its entirety consistent with a modern system, so advanced that it could also take into consideration environmental impacts?

This article is mainly based on archival sources and national professional journals. Articles in local newspapers from 1881 to 1921 were also reviewed.[5]

Different Types of Water Systems

Development stages of water supply and sewerage systems can be divided roughly into three systems and five stages. Used points of comparison must be from research subjects (water supply and sewerage) that are not only contemporary but also of similar technological level. The systems are roughly divided as follows (Juuti 2001):

1) Bucket systems — Symbolised by the bucket, reflects carrying.
2) Protosystems — Symbolised by the WC, reflects leaking and flushing.[6]
3) Modern systems — Symbolised by the drop with wavy lines, reflects water circulation (See Tables 2 and 3).

The purpose of this is to show that various solutions for city infrastructure, at different times, could have been feasible then. This way, we can also avoid a predestined, technologically deterministic view of water supply and sewerage advancing unavoidably towards the modern, "right" solution.

Table 2 shows the most characteristic features of the three systems. *The bucket system* is associated mostly with the use of buckets or similar vessels to draw, carry and hold water from wells, springs and various natural water sources like rivers, lakes and rainwater. Transportation of wastewater and refuse was also done with buckets to ditches, rubbish heaps and pits. The most characteristic feature of fire fighting during the bucket-system periods was the use of untrained people to put out fires with water transported by "bucket brigades".

BUCKET SYSTEMS 	**P**ROTO SYSTEMS 	**M**ODERN SYSTEMS 
-Water acquisition, fire fighting and sanitation based on bucket. -Functional when cities were sparsely populated like the countryside. -Still in use in the countryside. -In Finland until the turn of the 20th century, still in many developing countries. -Population density was increased by the period of rapid growth. -Inadequate constructional solutions: densely build blocks of wooden houses and later apartment houses caused pressures for change. -Also epidemics and unhealthy conditions caused pressures for change. Water acquisition, fire fighting and sanitation demanded solutions, otherwise the existence of the city would have been in danger.	-In the middle of environmental problems, great fires and heaps of refuse P was the attempted solution. P took the problems out of sight, but drawbacks were still there -Into the pipe, out of the pipe. -Solution demanded: a) understanding that there were problems in water supply b) will for change among decisionmakers c) understanding among the decisionmakers that the community should take care of these things -In Finland B prevailed to the First, partly to the Second World War. -Used still in countryside in some extend -Still in use in developing countries, partly with B, partly with M.	-Attempt to solve problems, not only transfer them somewhere else. -Ancient city cultures along with P, in Finland partly after the First, partly after the Second World War
TYPICAL FOR THE SYSTEMS:		
WATER SOURCE		
wells, springs, rivers and lakes, rainwater	usually surface water, lakes, rivers, etc., wells in the vicinity of the city, not in cities	groundwater or treated surface water, treating of raw water with rapid sand filtering
METHOD		
various buckets and vessels	-untreated piped or slow sand filtered to consumers -gravity water	-charge according to measured consumption -watertanks -disinfection -high-pressure water pipe network -developed management and maintenance system -democratic / undemocratic
SEWERAGE		
ditches	waste- and rainwaters in same system, untreated to closest water system	-separate sewer system -wastewater treatment
FIRE FIGHTING		
bucket brigade, fire guards	Volunteer fire brigades, fire guards, bucket brigade	hydrants regular fire brigade

Table 2. Three systems of urban water supply, sanitation, and fire-fighting.

	TIME	CULTURE	METHODS	OBJECT OF INTERESTS	SYSTEMS	VALUES
I Pre-urban systems 	Before cities, c.10 000 B.C. and later.	Gathering	Rainwater, spring water, bucket	Cleanness, comfort, pleasure	Survival	Survival
II Early systems  	c.10 000 B.C. to 500 A.D.	Several, first cities, Roman culture	Water pipes, water tanks, sewers, WC, aqueducts fire-brigade	Cleanness, comfort, pleasure	Modern system (drinking water) & protosystem (rain water)	Military values Rich and poor treated unequally, "undemocratic"
III Stagnation period 	c. 500 - 1700	Several, in Europe religious culture	Old modern and proto-systems break up, nothing to replace Chamber pot, rubbish heap, bucket Bucket brigades; fire guards	Society is interested in water supply	Bucket system, side by side with protosystem	Symbolic values
IV Period of slow development 	c. 1700-1910	Several, enlightenment, scientific-technological culture	Into the pipe, out of the pipe. First drainage,then water works.Slow sand filtering inv. in 1804, to use in 1829. Volunteer fire brigades and other arrangements alongside bucket brigades	Work efficiency, health, miasma. Since the mid- 19th century miasmatheory eclipsed by bacteriology, breakthrough of hygiene (Farr, Snow, Pasteur, Koch, etc.)	Protosystem, often alongside bucket system	Productional values
V Modern urban infrastructure 	Period of developed urban infrastructure, c.1910 to present	Several, enlightenment, scientific-tech-nological culture	Rapid sand filtering (dev. in1885) in extensive use. Bucket brigades replaced by regular firebrigades in substitution Bacteriology applied at water works. Treatment of waste water. Charging based on measured consumption, pressured network of water pipes, water tanks, hydrant networks. Developed management and maintenance systems.	Environment, health, hygiene, later ecology.	Modern system, often alongside protosystem.	Productional, later ecological values. Poor and rich in nearly same position, "democratic" system Finnish system: municipal ownership and consumer orientation (information sharing, etc).

Table 3. Periods of water supply and sanitation.

The period of rapid growth increased population density and demanded new constructional solutions. The densely built blocks of wooden houses, and later the first apartment houses, brought new challenges both for water supply and fire protection. Simultaneously, water acquisition, fire protection and refuse disposal demanded new solutions - otherwise the existence of the city would have been endangered.

In the middle of growing environmental problems, great fires that ravaged cities, and heaps of refuse, the *protosystems* were created to hide the problems. This solution demanded recognition of the fact that there were problems, and that the decision makers had the will for a change. They had to understand that the community should take care of these things. Drawing of water from the vicinity of the city, not from the city area, was typical for the protosystem. This meant, for instance, wells and leading untreated or mostly slow-sand-filtered water by gravity through pipes to consumers.

Other main features were the building of sewers to that untreated waste- and stormwater were led in the combined system to nearby water bodies and transportation of refuse to the immediate surroundings of the city area or dumping it in the water systems. Voluntary fire brigades were part of this period. The protosystem can be described by its operational principle: into the pipe, out of the pipe. As always with prototypes, there were defects and errors in the system.

Modern systems, on the contrary, were quite different from protosystems. They aimed at more sustainable solutions than protosystems. The central features were use of groundwater or treated surface water before leading it under high pressure to consumers, charging for water according to metered consumption, use of elevated water reservoirs, and the introduction of a separate sewer system and wastewater treatment. In this period fire fighting included the hydrant system within the city area and regular fire brigades.

Based on these classifications, the water supply system of Tampere is compared with those existing elsewhere in various periods both in Finland and abroad.

The development of water supply and sewerage has not progressed linearly from primitive systems to more complicated, or from "bad" to "good" ones. The growth period of the city, and especially preparedness of the community to take responsibility for water supply, have been central issues. In different time periods objects of interest and methods have varied according to need, readiness and what has been considered important.

First Attempts in Tampere

The first municipal "water pumping installation" in Tampere, and probably the whole country, was founded in 1835. The system was quite simple and constituted a so-called bucket system. The first water-protection regulation in Tampere concerned this system.[7] The rapid growth period in Tampere started a few years later.[8]

At the beginning, Tampere was like a farmhouse on a grand scale with pigs and cows. As the city grew, rural living habits began to disappear and the city began to lose its metabolic ties with the surroundings. Nutrients were no longer put back into circulation, for instance, to be eaten by pigs or to improve the soil. Instead, they were removed as refuse and deposited in rubbish heaps, dumps, and only later, in the water systems along the sewers. When there was no network of sewers, wells started to become polluted, and there was no longer enough pure water for people.

Polluted water and unhygienic living conditions created a favourable environment for epidemics, like the typhoid fever. The same sequence of events occurred also in several other European cities. Tampere is, however, an exceptional example because of the rapid growth made possible by industrialisation. Both the problems and their solutions soon became visible. Along with industrialisation the city grew rapidly; during the main research period of 1835-1921 the population rose from about 1,600 to over 40,000.[9]

The evolution of sewerage began with free-flowing ditches flowing from the northern parts of the old city to Lake Pyhäjärvi and the rapids. As years went by and Tampere grew, the ditches were straightened, opened and covered. These measures, however, proved to be insufficient and the dirt and filth continued to spread. The exacerbated problem forced the decision makers of Tampere to work out a plan for underground sewerage following the hygienic reform started in England and personified by W. Chadwick.[10] A transition from the bucket system to the protosystem thus began.

When the growth of the city accelerated due to industrialisation, problems began to accumulate: there was not enough water and what little there was, was of a poor quality. A discussion about changing this bad situation started. The first most visible measure in Tampere was the founding of the "Sundhetskommittén I Tammerfors" (Public health committee: Swedish was used as administrative language that time) called by contemporaries the "temperance committee". The committee started its work in 1866, inspired, for instance, by the example of London: members knew closely the reform started in England and aimed to adapt its doctrines in Finland.[11]

The local newspaper *Tampereen Sanomat* followed the work of the committee closely and considered its progress.[12] The first aim of the committee was to organise drainage in parts of the city. It proposed the building of a sewer network as a remedy and appealed to the fact that the typhoid problem was worst in the least drained area of the city. The committee's report clearly shows that the members' beliefs about the causes of disease were consistent with the miasma theory. According to this theory, diseases were born in wet and contaminated soil as organic material was getting digested. The construction of sewers was a way to get rid of this. Thus, the model came directly from England, not from any other city in Finland.[13]

The building of the sewers in Tampere started after four decades of discussion in 1876.[14] The 1879 public health decree obliged the city to prepare a plan for a sewer system commensurate with the estimated population within 10 years. The city administrators took seriously the deficiencies in the sewerage and the demands of the government: starting in the early 1880s the municipal health board repeatedly exhorted the city to expand and upgrade their sewerage system.

The construction of a water supply system in Tampere was, however, forgotten because of the failure of the system of 1835, until a fire raised the issue again in 1865 after destroying 30 houses. This was very important in Finland as well as in other Nordic countries, since those days most of the houses were wooden.[15] Then, the very same year industrialist Wilhelm von Nottbeck suggested to the City Board that a privately owned waterworks be constructed in the city due to the fear of fires. A tender was requested from von Nottbeck, because there already was a water pipe and sprinkler systems serving Finlayson's cotton mill owned mostly by von Nottbeck.[16]

Since the proposed privately owned waterworks would have meant a quite big financial risk to the city, the City Board decided to reject the proposal of von Nottbeck and to have the city build a water pipe for itself. This plan was presented in an editorial of local newspaper in 25. of June 1866 with descriptive heading "Lusted water leading".[17] This editorial was the first time the water question was treated extensively - especially that reasons of fire protection favoured the plant. Also usefulness and health concerns, although not argues for as vehemently, were in favour.

The discussion was now opened to cover both sewers and water pipes. Yet, the discussion started slowly. After the rejection, the city sought expert knowledge and contractors from the private sector, such as Mr. Malakias Pasi in 1874. This person was a rural entrepreneur who seemingly had made a lot of wooden constructions. The next year the City Board decided "to leave the matter of water leading to the committee". This meant the start of a new era in history of water supply in Tampere: ever since all plans and projects have been initiated by the city.[18]

At the end of the 1880s, the Finnish people followed closely the development of the bacteriological revolution and hygienic reform started in England. Slowly the miasma theory began to lose ground.[19] In this phase, discussion about the water question also started to become livelier. A. Ahlberg, a civil engineer and later the city's first health official, made in 1880 the first proposal consistent with the modern system. It was, however, rejected by

the city council. This was probably due to the public health decree issued a year before, although the proposal would have exceeded the requirements of the decree. The local newspaper *Tampereen Sanomat* commented on the proposal in a positive tone.[20]

Ahlberg's suggestion was the first extensive plan on water supply and sewerage. The argument covered all the central points of building a water pipe up to its social effects. Probably the greatest problem would have been the suggested house-specific water charge; metering was to be introduced later. Ahlberg aimed to satisfy the demand for water over a long time, not to provide a temporary solution to meet an immediate shortage. It would have been an extensive and far-sighted modern system, with only some features of a protosystem.[21]

Solutions and Their Effects

Water Question

The first actual waterworks in Tampere, a clear protosystem, was completed in 1882. In the construction no attention was paid to the critique presented by Ahlberg. The main newspaper in the city, *Aamulehti*, strongly advocated the establishment of the waterworks. This low-pressure system did not, however, meet the requirements and the working principles of a modern waterworks: it was rejected as poorly functioning and incapable of being expanded after extensive critique in the pages of *Aamulehti*. Especially the inadequate pressure, the quality of water and the selling of water without metering were problems. However, it had several principles of modern water works, although perhaps of lower technical standard.[22]

Tampereen Sanomat also treated the water question, but not as extensively (for example 27.2.1886). The increasing amount of newspaper articles and the information disseminated through professional papers made people understand that the problems in water supply and sewerage could be solved.

Frequent fires and the various epidemics gave city officials and inhabitants the determination needed to establish water and sewerage systems. In 1890 the city council of Tampere requested C. Hausen, the engineer of the Helsinki waterworks, to prepare a plan for a new high-pressure facility. The plan, based on latest research, was presented the same year, but was accepted only after a long debate in 1895.[23]

The facility was completed on 22.11.1898, but not on the scale of the original plan. *Aamulehti* followed closely the matter and urged that the decision be made, when the process became drawn out. The paper also monitored closely the building process and the opening ceremonies were publicised prominently.

The new high-pressure waterworks provided safety and comfort. However, since the suggested slow sand filtration was rejected and the outlets of the sewers were too close to intake pipes, the efficiency of the new facility was also its weakness: later typhoid fever spread fast over a wide area aided by the water pipe network. Security was essentially increased when a regular fire brigade was founded in Tampere the same year. The lack of water pipe had also caused various other difficulties, extra work and trouble. After the founding of the waterworks, it was a great relief for the city's inhabitants not to have to carry and transport water and also to get rid of the extinguishing duty after a transition period. This increased the comfort and security of the inhabitants. In Tampere this quite long process also improved, after some setbacks, the sanitary situation and the appearance of the city area (see Figure 2: i-iii).

In cities sufficient water for fire fighting became available only after the emergence of high-pressure waterworks and professional fire-brigades. This was the case both in Tampere and Oulu, since both cities had initially low-pressure waterworks. (Table 1) It is probable that the decisions in Tampere were known well in Oulu as the two cities followed closely developments in each other's water supply and sewerage. In addition, Tampere and Oulu used same external experts, like Hausen from Helsinki.[24] Networking of the experts in the Finnish water sector was quite advanced already in the last years of the 19th century. Besides, Finnish experts and civil servants went on numerous fact-finding tours abroad (Sweden, England and Central Europe) to familiarise themselves with the foreign solutions.[25]

Problems with water quality were also largely solved only after the introduction of high-pressure waterworks, although Tampere needed a severe typhoid epidemic before economically minded decision makers realised the necessity of efficient water treatment. There had been knowledge of proper equipment and the dangers of not having it for years as a result of the domestic expert network and the active foreign connections.[26]

In 1916, one year before the national independence, hundreds of people died which finally prompted the necessary decision to be made which *Aamulehti* had been determinedly advocating for (see Figure 2:iii-iv). In Helsinki, Hämeenlinna and Lahti related problems were not as great, because they did not use untreated surface water. Lahti was using good quality groundwater from the Laune spring, Hämeenlinna used groundwater from Ahvenisto and Helsinki used from the beginning surface water treated with slow sand filters. These modern

systems were thus safer than the one in Tampere. In addition, the other cities were taking care of their wastewaters in a modern way compared to the protosystem in Tampere: in Lahti the wastewaters from the entire planned city area were treated already in 1910. The facility in Lahti was the most advanced in Finland then. The systems in Hämeenlinna and Turku also surpassed the one in Tampere in most areas since they were using safer groundwater.[27]

Apparently economic interests also stirred up dispute since some people were afraid that the costs were going to be shared by everyone while only a few could enjoy the advantages. In Tampere there was no opposition against the waterworks at any point, only some details aroused criticism in *Aamulehti*. In Hämeenlinna the committee preparing the plan for the waterworks followed the principle of not forcing the facility on the public. It thought that the importance and necessity of the facility were so well known that no discussion was needed. This nearly destroyed the whole plan. With hindsight it can be said that the importance and necessity of the waterworks were not a big enough factor to sell it, at least, to the local newspaper *Hämeen Sanomat*.[28]

Sewerage Question

The other side of the water question, i.e., sewerage also had to be solved. The public health decree of 1879 obliged cities to do so since the act required that leveling of the city areas was to be carried out. In Tampere, engineer Bergbom and architect Calonius proposed in 1882 to the city council that the city should draw up a sewerage plan for the needs of the city west of the rapids. Engineer C.O. Helenius did make a plan, according to which sewers were to be built of bricks. A plan for a sewer for the city east of the rapids was completed in 1883 and for the rest in 1894. This is how the protosystem for sewerage was introduced - also the forerunner of a modern system.[29]

Although the wettest area of the city was drained and hygiene improved, lakes were still being polluted since wastewater was not treated. The bucket was replaced by a drainpipe, and the problems were flushed out of sight untreated to the nearest water systems as is typical of protosystems. Luckily wastewaters were not sued for irrigation like in Germany and France[30] at that time. This kept the groundwater unpolluted.

In the beginning of the 20th century the raw water basin of Tampere, Lake Näsijärvi, was polluted and typhoid epidemics were plaguing the inhabitants. The threat of typhoid fever and other diseases spreading through water was removed in 1917, the year of Finland's independence, when chlorination of water was started. There have been no typhoid epidemics in Tampere since then. The modern system did not, however, include collection and treatment of wastewater.[31]

The typhoid epidemic for its part made local decision makers examine the question of community and industrial wastewaters. For various economic reasons it was finally decided not to do anything about the wastewater at that time: it was assumed that the Tammerkoski Rapids could purify it sufficiently. Yet, the situation in Tampere was considerably better than in certain cities in Germany: in Tampere the amount of wastewater was only a fraction of the amount of supplied water.

The matter was taken up again only in the 1950s, and in 1962 the first wastewater treatment plant was completed in Rahola, for the western suburbs of the city. Then, finally, Tampere had a modern water and sewerage system in every respect, although it did not cover the entire city. *Aamulehti* was no longer keenly interested in the wastewater question: it mostly reported the decisions of various administrative organs. Interest was aroused again after the lakes became indisputably polluted by the turn of the 1960s.

Groundwater

During the typhoid epidemics, there were discussions about whether Tampere should begin to use groundwater, which in terms of healthfulness and taste was better than the water of Lake Näsijärvi. Extensive groundwater inventories were made in the surroundings of the city and a quite rich groundwater source was found in Vuohenoja.

The matter was considered and explored for a decade and active discussions were held at times. The result was, however, that in 1920 the city council finally abandoned the plans for establishing a groundwater intake in Vuohenoja. It was thought that the groundwater would not suffice for the needs of the growing city. *Aamulehti* followed closely the inventories. Mostly it referred to the decisions of various officials, but some writings favoured the groundwater option. After the decision, a solution other than groundwater had to be found, and in 1921 the city council approved the building of a plant using surface water with rapid sand filtration. The idea of using groundwater in Tampere was not reintroduced until the 1950s.[32]

The new Kaupinoja surface water intake was in a safe place, opened in 1928. The water from Lake Näsijärvi was chlorinated and filtered in sand filters. Another new plant for the western parts of the city was built in Mältinranta, upstream of the rapids in 1931. After World War II the water works grew rapidly. At the turn of the 1960s, precedence was given to the quality problems of raw water caused by forest industry pollution along the lake nearby. Lake Roine, situated in a neighbouring municipality, became the new source of raw water in 1972. In constituted at the time one of the best raw water basins in the country. It is planned that by 2008 a regional water supply system based on groundwater through artificial recharge will serve the city and its neighbours. Thus the question on whether to use ground or surface water has been there for a century (see Figure 2: iv-v).

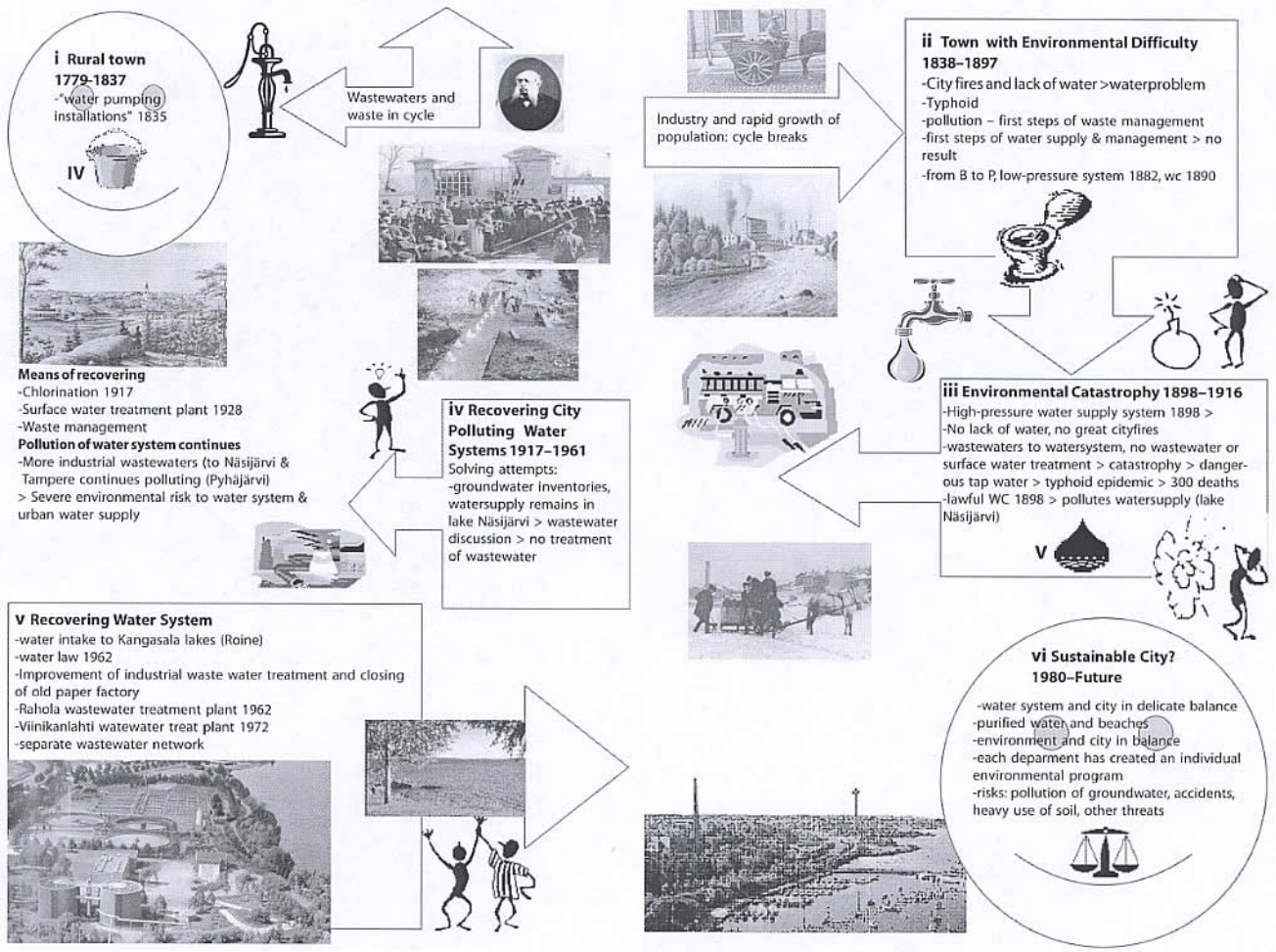

Figure 2. Echohistorical stages of Tempere. In this the environmental history of Tampere is divided into six phases. Phases i to ii belong to the Period of Slow Development of the water supply (cf. Table 3). The same two phases fall into the category B and end of ii to P (cf. Table 2).

i. *Rural Town, 1779-1837. After this period, fast industrialisation and urbanisation started followed by*

ii. *Town with Environmental Difficulty/disadvantages, 1838-1897.*

iii. *Environmental Catastrophe: City of Tampere, 1898-1916, in this period the city acquired a modern urban infrastructure (Table 3) and M (Table 2), but incomplete M and, thus, a very dangerous system.*

iv. *Recovering City, Polluting Water System, 1917-1961. In this period M system is fulfilled and treatment of industrial wastewater started.*

v. *Recovering Water System, 1962-1980s, in which the water systems began to recover because of wastewater treatment and changes in industrial processes. Modern system is completed with the separate sewer system.*

vi. *Adjusting City, 1980-2010, where water systems and city environment are in delicate balance.*

(Source: Juuti, 2001; Archives of Tampere City Museums)

Main Decisions and Their Effects

In Tampere many decisions have been made on water and wastewater management that have affected the development and the environment:

Strong industrialisation made the city grow rapidly and, thus, created also problems. Industry needed vast amounts of water while the city water supply was still at the bucket system level. The biggest factories built their own proto-level systems. The actions, on the whole, were initiated by demand.

The waterworks were born as a solution to the water question after long discussions, often after various, inadequate and temporary solutions. In terms of quantity there was enough water, and the selected technological, administrative and economical solutions were also successful. The well-being of people improved compared to the earlier situation and equality between them increased as waterworks expanded and better quality water slowly reached also working class people.

The waterworks was excellently suited for the needs of fire fighting. There were no great fires in the city after the founding of waterworks and fire department. The choice of the pressure level, the charging based on metered consumption, the selection of materials and machinery, the working methods and the financing of the project were especially successful in Tampere.

The biggest threat to people was removed when the chlorination of raw water started after the typhoid epidemics in 1917. More efficient water treatment followed after some years and improved the situation even more. On the national scale, the health situation improved after the founding of the waterworks, especially typhoid fever cases decreased with the exception of a few epidemics and civil war periods in 1918. In 1919 infant mortality was lower in the cities than in the countryside; earlier the situation was the reverse. At least in this respect, the cities had become healthier places to live than the countryside.

The environmental threat began to decline only after improvements in industrial processes and the building of the Rahola wastewater treatment plan (1962). Modern environment protection demanded decades of planning and extensive co-operation with the city, industries and other stakeholders. This has, however, been successful and the beaches are again in good condition. Also experimental plantings of crayfish have been made with success.

Certain strategic selections have had an effect on the environment, health and security and have also closed out other possible development paths or options for decades to come. At least the following selections belong to this group:

- A decision was made in 1866, and again in 1875, to solve the water question, by a water-pipe network under municipal ownership. The decision could quite well have been different, and the waterworks could have operated as a private enterprise like, for instance, in France, and later also in England. When comparing the situation in water supply in the 1990s, on the other hand in France and England, and on the other in Finland, and especially when taking into consideration the direct income from the municipal water works and the health effects for the city, one could say that the solution was the right one, at least from the viewpoint of the inhabitants.
- The modern plan by Ahlberg in 1880 was rejected, and a cheaper and inferior low-pressure solution was selected. It proved to be only temporary. This protosystem was realised in 1882.
- Despite the plans, the water treatment filters were not constructed. This highly questionable savings combined the wrong point of discharge of wastewater led in the end to the loss of 53 lives in the 1908-09 typhoid epidemic and nearly 300 in the 1916 epidemic.
- A groundwater project was abandoned in 1920, probably leading other cities also to use surface water. The choice in 1920 was made for the water source believed to be sufficient according to the knowledge at the time. This point was important, because during the dry seasons, even the waterworks could not always ensure the water supply of the cities. For instance, Turku had a shortage of water in the 1920s. Similar situations prevail now in many developing countries and even in some European countries. Cairo and Lagos in Africa, Dacca, Shanghai, Mumbai (Bombay), Calcutta, Jakarta and Karachi in Asia, and Sao Paulo and Mexico City in South America will face the greatest difficulties unless a quick solution is found. Water-related problems do not concern only developing countries. It could be said that the solutions for water supply are not as much tied to a time and a place than to the developmental stage of a society and its infrastructure.
- The treatment of wastewater was also studied around 1920, but it was taken seriously only some 30 years later. The wastewater situation was good compared to the German cities examined: the proportion of wastewater to clean water was very small.

The models and the knowledge in support of the various solutions were collected both from abroad and other facilities in Finland. The perception of the determining role of capital, even the perception of it as a precursor in this sector, proved to be misleading, if not incorrect. Capital has, of course, played an important, but not necessarily the only and central role.

Discussion and Implications

The study shows how the technical principles of the water supply have remained nearly the same as in the days of ancient Rome: a simple water pipe and a sewer network follow wells and rubbish heaps. During the last hundred years, water treatment and disinfection have been added to the methods of Rome, and in the final stage, if even then, a wastewater treatment plant has been built. The bucket is slowly replaced by a pipe, the protosystem supplemented or replaced totally by the modern system, as in Tampere.

The growing cities of developing countries seem to be repeating the Finnish pattern in building their water supply. First, they build a water pipe to replace wells, then sewerage to replace ditches. At this point, diseases like cholera and, especially typhoid fever, very often plague growing cities. The excessive use of water, the assessment, the lack of maintenance, etc. also cause problems. Only after the occurrence of these problems, the systems are built to guarantee good quality of water, and only lastly - usually after yet further problems- a wastewater treatment plant is built.

Examples of successful and durable solutions in water supply are nevertheless available. In this sense, water knows no limits - neither in place nor time. It is noteworthy how similar the problems in many developing countries are at the beginning of the 21st century compared to those faced earlier by developed countries. The underlying factors are the same in both cases: rapid growth of cities and inadequate resources.

D. Okun, a grand old man of water management, mentions five principles of sustainable water supply: (1) The uniqueness of water projects, (2) Efficiencies and economies of the scale, (3) Integration of water supply, sewerage and pollution control services, (4) Sound financial policies, and (5) A preference for pure rather than polluted sources of portable water.[33]

Compared those with the developments in Tampere, at least the Principles 1. and 2. had been applied successfully. Local expert knowledge was used amply and the adaptation was tailed for the conditions of Tampere - even too much considering the elimination of slow sand filtration. The dimensioning of the 1898 waterworks was a success, even if there was some criticism during the planning period. The estimates of the planners and specialists about the growth of the city and the capacity and extension possibilities of the waterworks needed proved to be correct.

The combining of water acquisition, sewerage and environmental protection started on the threshold of the crisis of 1909. Ever since that year, the food inspection office of the city supervised the quality of water in Tampere. It was decided to finance the activity on the basis of metered consumption (cf. Okun's principle 4.) following the failed system of lot-based charging with the low-pressure solution. This has made possible the sensible development of the utility, which probably would not have been possible in light of the examples with other charging principles.

Principle 5. is the most delicate issue in the history of the water supply in Tampere: preference was not given to better quality groundwater in spite of various warning signs, but the decision makers stuck with untreated surface water which contained unclean wastewater. The result was a catastrophe, from which it took the city a long time to recover. And even then better quality groundwater was not used - mainly because of the quarrels among specialists. Treated surface water and a better protected intake area were chosen instead of groundwater. Only decades later did groundwater become part of the water supply of Tampere.

These principles are mainly related to the city water supply and sanitation. Bigger industries like pulp and paper mills have traditionally had their own systems although they used to have some connections to the city water works at certain stage.

Conclusions

This paper has concentrated on the birth and early development of community water supply and sanitation in Tampere. Out of development the following conclusions can be drawn:

- Surface water was initially taken from nearby sources, and as these became contaminated, from farther away. The utilisation of groundwater started later, and artificial groundwater will likely be produced in the future.

- Wastewaters polluted the water system until their efficient treatment started at a relatively late. The industry began to protect waters later by increasing co-operation with the waterworks when the time was ripe.
- When the increase in the water consumption leveled off, the emphasis shifted to water quality.
- Mistakes have been made, but lessons have also been learned. It is better to do something than to do nothing.
- In environmental matters the utility has played and will continue to play, a key role in Tampere and its surroundings.

All in all, Tampere city waterworks is an example of a public utility owned by the users themselves that has been, and will continue to be, capable of providing services at reasonable cost. The utility has decisively improved the city's fire safety, hygiene and health conditions, and the quality of the city environment. It has also been central in enhancing the operating conditions of industry and commerce. Although many facilities of the works are hidden underground, we all come daily into contact with its key products: potable water, wastewater, cleaner water bodies and easier and safer everyday life.

Notes

1. Voionmaa V., Tampereen kaupungin historia II: Tampereen historia Venäjän vallan ensipuoliskon aikana. (Tampere, 1929), 481.
2. Juuti P. & Katko T., Ernomane vesitehras. Tampereen kaupungin besilaitos 1835-1998. With English summary Marvelous water factory - Tampere City Water Works 1835-1989 (Tampere, 1998), 9-72, Juuti P., Kaupunki ja vesi. With English summary City and Water (Pieksämäki, 2001), 182-190.
3. Juuti 2001, 12, 138-164.
4. Katko T., Vettä! - Suomen vesihuollon kehitys kaupungeissa ja maaseudulla (Tampere, 1996), 45, 102.
5. The initial case study was Juuti & Katko 1998 and the further doctoral dissertation Juuti 2001.
6. Classification by Juuti 2001. The division of the stages, especially during the so-called stagnation period, applies mainly to Europe and USA.
7. Tampere city record office, minutes of city administrative court 3.4.1838.
8. Rasila V., Tampereen historia II. 1840-luvulta vuoteen 1905 (Tampere, 1984), 131.
9. Rasila 1984, 131.
10. See Hamlin C. 1998. Chadwick and sanitary movement in the U.K.
11. Tampere city record office, minutes of city administrative court 27.11.1866; Juuti 2001, 67-70.
12. Tampereen Sanomat 5.3.1867.
13. Tampere city record office, minutes of city administrative court 30.1.1867; Porter D., Health, Civilization And The State. A history of public health from ancient to modern times (London & New York, 1999), 79-82; Juuti 2001, 70-71.
14. Tampere city record office, minutes of city council 18.8.1875; Juuti 2001, 71.
15. See Jutikkala E., "Great Fires of Finnish Cities" in Körner M. (ed.) Destruction and Reconstruction of Towns, Volume 1 (Bern; Stuttgart; Wien: Haupt, 1999), 239-254.
16. Tampere city record office, minutes of city administrative court 18.10.1865, 22.11.1865; Juuti 2001, 73-75.
17. Katko T., Juuti P. & Hukka J., "An early attempt to privatise - any lessons learnt?" Research and technical note. Water International. Vol. 27, no. 2 (U.S.A., 2002), 294-297.
18. Tampere city record office, minutes of city administrative court 28.9.1874; Juuti 2001, 77-79.
19. K.F.M. in Duodecim 1885, number 6-7, 66-73, number 8-9, 92-131; Terveydenhoitolehti 1897, numbers 1, 3, 6, 8-9; Juuti 2001, 85-87.
20. Tampere city record office, minutes of city council 21.4.1880; Tampereen Sanomat 10.3.1880.
21. Juuti 2001, 79-82.
22. Juuti 2001, 82-86; Aamulehti 19.4.1882, 25.4.1889, 27.7.1890 etc.
23. Juuti 2001, 113-127.

24. Katko 1996, 52; Juuti 2001, 141-164.
25. See Hietala M., Services and Urbanization at the Turn of the Century. The Diffusion of Innovations (Helsinki, 1987).
26. Koskinen M., Saastunut Näsijärvi terveydellisenä riskinä - Kulkutaudit, kuolema ja puhdasvesikysymys Tampereella 1908-1921. Master thesis (University of Tampere, 1995), 54-55, 64, 77; Juuti 2001, 140-164, 182-185.
27. Aamulehti 16.4.1915; Koskinen 1995, 54-55; Juuti 2001, 140-164, 182-185.
28. Juuti 2001, 155-164.
29. Tampere city record office, minutes of city council 25.5.1887; Juuti 2001, 90-100.
30. Reid D. 1991, Paris Sewers and Sewermen. Realities and Representations. (Harvard University Press, 1991).
31. Juuti 2001, 182-185. The inhabitants of the peripheries were not necessarily in a worse position than the inhabitants of city centre. The peripheries relied for long on wells and latrines. For instance, in the suburb of Pispala, people organised water distribution based on a clear protosystem managed by a local cooperative. They largely escaped the great typhoid epidemics in Tampere, mostly due to their isolation. A somewhat similar case occurred in 1892 in Altone-Hamburg, in Germany where people living in adjoining areas were saved from cholera depending on whether they drank treated or untreated water. A system does not necessarily have to be of a high technical level, if the water source is protected or isolated. But surface water must be treated. Evans R., Death in Hamburg. Society and Politics in the Cholera Years 1830-1910 (Oxford, 1987), 189-192, 289-299.
32. Juuti & Katko 1998, 101-107; Juuti 2001, 190-194.
33. Okun D. A., Regionalization of Water Management. A Revolution in England and Wales (London, 1977), 4-7.