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Water supply and quality of drinking water in Moscow in the 19th – early 20th centuries

Abstract. The article is devoted to the development of centralized water supply in Moscow from the opening of the gravity-flowing Ekaterininsky (Mytishchinsky) water pipeline with spring water in 1804 to commissioning of Moskvoretsky water pipeline in 1903–12, which supplied the city dwellers with purified water from the Moskva River. Along with the centralized water supply, attention is also paid to the traditional forms of decentralized water supply with the delivery of water by water carters and the consumption of unfiltered water from open reservoirs and dug wells by the city dwellers. Attention is paid to the quality of drinking water, which was considered during the construction and reconstruction of Moscow water pipelines, formation of long-term plans for the development of water supply, protection of water supply sources from pollution in the context of sanitary measures to protect the population from epidemic diseases.

Keywords: water supply, water pipeline, water carter, spring water, ground water, quality of drinking water, water hardness, water filtration, Moscow, water and sanitary inspection

Introduction

Studies on the retrospective analysis of the establishment and development of water supply systems in cities, the role of water supply in sanitation and improving the quality of life of city dwellers, changes in lifestyle and traditional approach to water use as a result of introduction of centralized water pipelines have become a popular trend among the historians of different countries in recent years, in Europe and the US in the first place, including within the framework of the studies of urban environmental history. These scientific works, which uniquely connect the humanities scholars and the sphere that previously belonged exclusively to the interests of 'techies' and hygienists, allow us to consider water supply on an interdisciplinary basis as

a vital factor in the development and transformation of cities and urban communities. It will suffice to mention several scientific publications of the last decade on this subject, to convince ourselves of the relevance of the subject of research and of unfailing interest to it from the historians studying the problem of water supply in the context of relationship between the society and nature[1].

In Russia, attempts to study the history of urban water supply have been undertaken repeatedly[2]. Now, this topic has acquired a second wind in the work of a new generation of researchers analyzing the history of water supply in the cities of Russia from a new angle[3].

Researchers have been involved in the studies of Moscow water supply for a long time, but their work was generally of a narrowly focused nature and concerned the issues of construction and development of water pipelines as the most technologically complex and advantageous elements of water supply system from the point of view of public attention[4], or specific aspects of water supply, such as search for prospec-

[1] Angelakis F.N., Mays L.W., Koutsyiannis D., Mamassis N. *Evolution of Water Supply Through the Millennia.* Leningrad: IWA Publishing, 2012; Broich J. Engineering the Empire: British Water Supply Systems and Colonial societies, 1850–1900. *Jounal of British Studies*, 2007, vol. 46, Issue 2, pp. 346–365; Broich J. *London: Water and the Making of the Modern City*. Pittsburg, 2013; Petris S. Juuti, Tapio S. Katko, Heikkis Vuorinen. *Environmental history of water: global views on community water supply and Sanitation*. Leningrad: IWA Publishing, 2007; Tallo E., Ostos J. Water consumption in Barcelona and its regional environmental imprint: a long-term history (1717–2008). *Regional Environmental history change*, 2012, vol. 12, issues 2, pp. 347–361; Tomory L. London`s water supply before 1800 and the Roots of the Networked City. *Technology and Culture*, 2015, vol. 56, no. 3, pp. 704–737; Tomory L. *The History of the London water Industry*, 1580–1820. Baltimore: Johs Hopkins University Press, 2017; Smith C. *City Water, City Life: Water and the Infrastructure of Ideas in Urbanizing Philadelphia, Boston, and Chicago*. Chicago: University of Chicago Press. 2013; Soll D. City, region, and in between: New York City`s water supply and the insights of regional history. *Journal of urban History*, 2012, vol. 38 (2), pp. 294–318; Soll D. *Empire of Water: An Environmental and Political History of the New York City Water Supply*. Cornell University Press, 2013.

[2] Del'vig A.I. Historical review of art to conduct water: water pipelines in Russia. *Bulletin of industry*, 1859, vol. 2, no. 4, April, part III, pp. 1–54; Fal'kovskii N.I. *History of water supply in Russia*. Moscow-Leningrad, 1947 and others

[3] See, for example: Agafonova A.B. Traditional society and problems of water supply in provincial cities during the modernization of the last third of the 19th – early 20th centuries (on the materials of Vologda and Novgorod). *Traditional Society: An Unknown Past: Materials of the 10th International Scientific and Practical Conference, March 21–22, 2014*. Chelyabinsk, 2014, pp. 194–197; Il'in A.Iu. The origin and development of water supply systems of Russian provincial centers in the 18th – 20th centuries (on the materials of Penza, Ryazan and Tambov). *Socio-economic phenomena and processes*, 2016, vol. 11, no. 10, pp. 28–34; Kos V.V. Water supply of a provincial city at the turn of the centuries (on the example of Tomsk province at the end of the 19th – early 20th centuries). *Bulletin of the Kemerovo State University*, 2013, no. 2, pp. 50–55 and others

[4] Del'vig A.I. *Moscow water pipelines in 1859*. Moscow, 1860; *Water supply of Moscow in 1779–1902. Mytishchinsky and other auxiliary water pipelines.* Moscow, 1902. Nesteruk F.Ia. *Water construction in Moscow*. Moscow, 1950; Rerberg I.F. *Moscow water pipeline. A historical*

tive sources, water supply and hygiene of drinking water[5]. Some of these works were written by specialists in the sphere of water supply, as a rule, to the jubilee dates and carried the imprint of departmental publications[6].

Without setting the goal of providing a detailed description of the history of Moscow water pipelines and water carters, the article focuses on the problems of the quality of drinking water in the context of formation of the centralized water supply in the pre-Soviet period, starting since the commissioning of the Ekaterininsky (Mytishchinsky) water pipeline in 1804 and finishing with the commissioning of Moskvoretsky water pipeline in 1903–12. In the era when the local sources of water supply were subjected to powerful anthropogenic impact because of industrial revolution, industrialization, urbanization and population growth, the quality of water had become the subject of focused attention. From this point of view, it is very important to study the history of water supply in Russia's largest megalopolis on an interdisciplinary basis, considering the ways it had been formed under the influence of assessing the quality of the drinking water and the sanitary status of water supply sources, and how this in its turn changed the daily life and customary use of water by the city dwellers.

Main body

Until 1804, Moscow water supply was based on the use of water resources from open natural sources: rivers, streams, ponds, as well as from the wells – spring wells and artificially dug wells with ground water. Housing estates that were remote from the water sources were served by water carters, which already in the 17th century became an indispensable attribute of the daily life of the citizens[7]. In the medieval Moscow there were examples of construction of small local gravity and pressure water pipelines. It is known, for example, that in 1631–33, the first pressure water pipeline in Russia was built in Moscow by master Christopher Galloway, and it existed until the 18th century. The pipeline, with the help of a water-lifting machine, supplied water to the reservoir in the Kremlin, from where it was distributed through a system of lead pipes. Pressure water piping was built in the royal palace in Kolomenskoye as

sketch of the consctruction and development of water supply in Moscow and a description of a new water pipeline. Moscow, 1892 and others.

[5] Vasil'evskaia O.V. *History of water supply of Moscow in hygienic treatment: Doc. dis.*, Moscow, 1952; Ozerova N.A. To the history of water supply of Moscow: 'The search for new sources' in 1913–1930. *Issues of the history of science and technology*, 2010, no. 1, pp. 75–94.

[6] See, for example: Khramenkov S.V., Volkov V.Z., Gorban' O.M., Kalashnikova E.G., Fomushkin V.P. *From the Source to Moscow*. Moscow, 1999; Khramenkov S.V., Sigin A.P., Sadova N.I., Blagova O.E. *200 years of Moscow water supply*. Moscow, 2006.

[7] Fal'kovskii N.I. *History of Water Supply in Russia*. Moscow-Leningrad, 1947, p. 83.

well. The practice of construction of open water drains also began to be actively spread in the same era[8].

The facilitators of medieval water pipelines solved narrow utilitarian tasks and did not set themselves as a goal the mass water supply to the urban population. The most famous authority in the matters of water supply, Baron A.I. Delvig, noted that until the 18th century, there were no water pipelines built in Russia because of the cheap labor of serfs, lack of sufficient financial resources and required knowledge of hydraulics as well as due to climatic pattern[9]. A major specialist in the history of Russian water supply, N.I. Fal'kovskii, believed that Russian people had been familiar with water pipelines from the old times, "however favorable local conditions made it possible to dispense with simpler methods of water supply"[10].

In medieval Moscow, the favorable conditions were represented by the presence of abundant water resources suitable for drinking and cooking without any threat to health. As an example, the water from the Presnensky Ponds was considered the best until the 17th century and went exclusively for the table of Tsar Alexei Mikhailovich (Alexis of Russia)[11], whilst in the following centuries these ponds became some of the most polluted.

During the 17th–18th centuries, the quality of water in the local water reservoirs and wells had changed for the worse because of the growing pollution of the urban environment with household waste and sewage. The ground water became 'unhealthy' under the influence of a powerful anthropogenic load on the upper and lower layers of the soil, which intensified as the population grew. The absence of a city-wide waste management system, the leakage of sewage into the soil through the cracks, as well as through the ways made by rats and other animals near the cesspits and cesspools, contributed to contamination of aquifers and water damage in the wells. As the contemporary wrote, "in Moscow, a well with good water is a perfect rarity, a precious treasure; whoever has it, he / she boasts of it like of a rich mine streaming silver and gold[12]. Although in the 18th century, people were already able to improve the water by desilting and filtering it, as well as by subjecting it to boiling[13],

[8] Ibid, pp. 84–89.
[9] Del'vig A.I. Historical review of art to conduct water: Water pipelines in Russia. *Bulletin of industry*, 1859, vol. 2, no. 4, April, part III, p. 1.
[10] Fal'kovskii N.I. *History of Water Supply in Russia*. Moscow; Leningrad, 1947, p. 40.
[11] *Water supply of Moscow in 1779-1902. Mytishchinsky and Other Auxiliary Water Pipelines*. Moscow, 1902, p. 1.
[12] Ibid, pp. 225–226.
[13] Verzhbdlovskii M.V. *Essays on the History of Water Hygiene in Russia and the USSR (1700s–1960s): Synopsis of the thesis for the degree of a doctor of medical sciences.* Leningrad, 1966, pp. 7–8.

nevertheless, during the spring floods, "a significant increase in mortality, which occurred solely from the absence of any satisfactory water"[14], was recorded in the city.

It is worth noting that the assessment of water quality was determined at that time by an organoleptic method using the five sense organs in human being. They checked water on the surface. Attention was paid to its transparency, color, smell and taste[15]. From the middle of the 18th century, they began to add the results of chemical studies to the organoleptic indicators, on the presence of samples of inorganic substances in the water, which were then recognized as disease carriers[16].

Under the conditions of pollution of the dug wells, the resources of clean water from spring wells were no longer sufficient for all those who were traditionally accustomed to the use of river, pond and ground water. The most abundant Andreevskie springs (30 thousand buckets per day) and Trekhgornye springs (18 thousand buckets per day)[17], could give the city 576 cubic meters of water in aggregate, calculated as a 12-liter bucket used throughout Russia. The springs in Devichye Pole (a well called Babylon), Presnenskie, near the Andronievsky Monastery, on the Vvedensky Mountains, behind the Rogozhskaya Gate and a few others gave much less water.

Private water carters delivered water from the spring wells in barrels for a decent fee, which only wealthy citizens could afford. In particular, a small wealthy family living in the Kremlin area spent at the turn of the 18th–19th centuries on delivered water up to 60 rubles per year, i.e. 50 kopecks for a barrel, which was enough for three days[18]. The poorest urban strata could not afford such an expensive drink, and, according to a contemporary, "...took it for all the needs from the Moskva and Yauza rivers, from stagnant ponds and some wells, and used water either hard and unpleasant, or not fresh and turbid, or rotten and unhealthy..."[19].

Consequently, by the end of the 18th century, the population of Moscow already experienced a serious shortage of clean drinking water, which could be compensated only by the implementation of the water pipeline project aimed at uncontaminated sources of water supply. Such a project, approved by Empress of Russia, Catherine the Great, was developed and began to be implemented in 1779 by a talented hydraulic engineer, Lieutenant-General F.W. Bauer. Considering that a lot of works had

[14] *Water supply of Moscow in 1779–1902. Mytishchinsky and Other Auxiliary Water Pipelines*. Moscow, 1902, p. 2.
[15] See: Fal'kovskii N.I. *History of Water Supply in Russia*. Moscow; Leningrad, 1947, p. 15.
[16] Verzhbdlovskii M.V. *Essays on the History of Water Hygiene in Russia and the USSR (1700s–1960s): Synopsis of the thesis for the degree of a doctor of medical sciences*. Leningrad, 1966, pp. 7–8.
[17] *Water supply of Moscow in 1779–1902. Mytishchinsky and Other Auxiliary Water Ppipelines*. Moscow, 1902, pp. 2–3.
[18] Mytishchinsky water conduit in *Vestnik Evropy*, 1804, no. 23, p. 226.
[19] Ibid, p. 226–227.

been devoted to the construction of that water pipeline[20], we shall remind that the project assumed the use of water for water pipeline from the springs located near the village of Bolshie Mytischi, 15 versts away from Moscow. The choice of the location for the construction of the water wells was due to a higher location of this place in relation to the city, which made it possible to guide the water through an artificial water conduit by gravity, without boosting it with pumps. An important factor in the choice of the springs was also the unsurpassed quality of the local Mytishchi water – tasty, healthy and having a constant low temperature[21]. A.I. Delvig noted that even tea in this water came out better than in the spring water from the Trekhgorny well[22].

After the death of F.W. Bauer, the construction with the support of the Emperors Paul I of Russia and Alexander I of Russia was continued by the engineer J.C. Gerhard. On 28th October 1804, water from the Mytishchi springs was sent to the city via a brick water conduit, which was laid with the use of several artificial embankments, aqueducts and other engineering structures. On its way, the water had to be taken by the population, and water carters from the fountains and wells built with specific purpose. Initially, it was planned to supply 330,000 thousand buckets of spring water per day to Moscow, which, with the city population estimated at 250,000 people, meant approximately 15 liters of clean water per inhabitant[23]. Together with the reserves of local water used for household needs, this amount should have been enough for the citizens not yet spoiled by the drainage.

It is important that the construction of the Ekaterininsky (Mytishchinsky) water pipeline was dictated, first, not by the shortage of water in the city, but by the poor quality of local water resources. This was asserted by Baron A.I. Delvig half a century after opening of the water pipeline, when he wrote that in Moscow "...there was a shortage not in quantity, but in quality of water..."[24].

Muscovites reacted to the opening of the first water pipeline with optimism and somewhat exalted enthusiasm. As one of the anonymous authors wrote in the journal *Vestnik Evropy*, "...the water conduit opened, and now Moscow is rich in water, clean and perfect, fresh and healthy, transparent and flowing: its need is satisfied, the only, but very important need, and the first capital city of Russia does not envy now either Rome, irrigated by the majestic Tiber, nor London, ascending on the shores of the

[20] See, for example: Del'vig A.I. Historical review of art to conduct water: Water pipelines in Russia. *Bulletin of industry*, 1859, vol. 2, no. 4, April, part III, pp. 1–54; Fal'kovskii N.I. *History of Water Supply in Russia*. Moscow; Leningrad, 1947: Publishing House of the Ministry of Communal Services of the RSFSR, 1947 and others.

[21] *Water Supply of Moscow in 1779–1902. Mytishchinsky and Other Auxiliary Water Pipelines*. Moscow, 1902, p. 3.

[22] Del'vig A.I. Historical review of art to conduct water: Water pipelines in Russia, *Bulletin of industry*, 1859, Vol. 2, no. 4, April, part III, pp. 8–9.

[23] Ibid, p. 2.

[24] Ibid.

high-water Thames, nor St Petersburg, drinking the Neva water and towering at the most glorious and beautiful river in Europe"[25]. The river water used in the water pipelines of Western Europe could not compete in quality with the water of the Mytishchinsky water pipeline.

At the same time, Mytishchinsky water pipeline had some design flaws, which led to both loss of water and deterioration of its quality on the way to the city. The wooden beds at the base of the water conduit became rotten, and its brickwork, under the influence of rains, spring floods and frosts, began to sag leading to cracks and collapses, through which water drained away. The quality of water deteriorated as the area of Sokolnichya grove passed, where it was diluted with the local ground water, which penetrated through the cracks and gaps in the plaster of the water conduit buried at this point in the ground to maintain the angle of inclination. From the Samoteka ('place of gravity-flowing water') to the Pipe (which is the contemporary Trubnaya square), the quality of water reduced even more because of penetration of sewage into the water conduit[26]. In the first decades when the water pipeline existed, it was even forbidden to connect private houses to it "...for the reasons that the water pipeline was built for the community, and not for certain people, and that to remove water from it causes its clogging and decay by weakening the flow"[27]. The documents show that considerable financial resources were spent annually for repairing the water conduit and its cleaning from dirt and other contaminants[28]. In 1823, the water conduit completely collapsed and became covered with sand and soil for 3.2 km near Alekseevskoye village near the Sokolnichya grove[29].

In 1826-35, the Governor of the Third District of the Railways, military engineer N.I. Janisch, arranged the improvement of the water pipeline. In particular, Alekseevskaya pumping station was constructed, which supplied good quality water to the reservoir of the Sukharevskaya Tower by means of steam engines, passing the Sokolnichya grove, and from there it flowed by gravity into the city distribution fountains along the cast-iron water conduit. The pumped water initially amounted to 180 thousand buckets per day (2160 cubic meters), but gradually ran low, decreasing by July 1854 to mere 35 thousand buckets (420 cubic meters)[30].

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[25] Mytishchinsky water conduit. *Vestnik Evropy*, 1804, no. 23, p. 227.

[26] For more details, see: Maksimov. A note on the new transformation of the Moscow water pipeline according to the highest approved project of engineer-major-general Janisch. *Journal of Communications*, 1840, vol. 3, Book 2, pp. 155–159.

[27] Central State Archives of Moscow (CSA of Moscow), F. 47, Op. 2, D. 72, L. 21 ob.

[28] See, for example: CSA of Moscow. F. 48. Op.1. D. 24 The case of clearing the sediments and clogging of part of the old brick water pipeline from the Sokolnichya Grove to the tract in Moscow city called as the pipe.

[29] Fal'kovskii N.I. *History of Water Supply in Russia*. Moscow-Leningrad, 1947, p. 168.

[30] CSA of Moscow, F. 179, Op. 60, D. 1, L. 14.

In connection with the poor supply of Mytishchi water, the ban on the connection of households to the water pipeline was still effective, and water could only be taken from the distribution fountains and wells. Even N.I. Janisch, despite all his merits in the water supply field, could not connect a water pipe to his house[31]. Exceptions were made only for some owners of bathhouses, considering the public significance of these establishments for the health of the population, and only from those volumes of water that were dumped into the drains as excessive, i.e. not taken from the fountains and wells.

By the middle of the 19th century, the limited supplies of Mytishchi water forced the attention of the authorities to the Moskva River as a potential source of water resources. In May 1850, under the leadership of the director of the water pipeline, General-Colonel P.S. Maksimov, two water intakes were built on the river around the Babyegorodskaya Dam and at the old mouth of Obvodny Canal near the Krasnokholmsky Bridge. The first water intake supplied 33 thousand buckets of water per day to the fountains arranged in the central part of the city, and the second supplied 100 thousand buckets per day to five fountains of Zamoskvorechye. The technologies of river water filtration in the middle of the 19th century were not developed yet, so the river intakes pumped water of deliberately low quality into the pipes. During the spring flood, the water intakes did not work, as turbid water became unfitted and even dangerous for the consumption. Thus, in the spring of 1860, the intakes did not work for 45 days[32]. A.I. Delvig repeatedly asked the Moscow governor-general to liquidate the floats for washing clothes near the Krasnokholmsky bridge upon the pretext that "...the water in the wells of Zamoskvoretsky water supply, while washing on the floats, is impure and has a bad smell. Even patches of dirty laundry reach them..."[33]. The low quality of drinking water in combination with technical problems caused the gradual closure of these water intakes after the modernization of the Mytishchinsky water pipeline, carried out under the guidance of A.I. Delvig in 1853–1858.

A.I. Delvig increased the supply of quality Mytishchi water to the city to 505 thousand buckets per day[34] (six thousand cubic meters), having achieved such an effect by lowering the level of ground water in the catchment basins and the installation of two cast-iron conduits from Alekseevskaya pumping station. The delivery of water by water carters became easier; private households finally received permission to connect to the water pipeline since 1858. However, the water pipeline served only part of the city on the left side of the Moskva River.

[31] Del'vig A.I. *Moscow Water Pipelines in 1859*. Moscow, 1860, p. 19.
[32] Del'vig A.I. Moscow water pipelines in 1860. *Bulletin of industry*, 1861, T. XIII, no. 7, p. 8.
[33] CSA of Moscow, F. 16, Op. 14, D. 65, L. 57 ob.
[34] Del'vig A.I. Historical review of art to conduct water: Water pipelines in Russia. *Bulletin of industry*, 1859, vol. 2, no. 4, April, Part III, p. 40.

Whilst noting the gratitude of the poorest layers of the population for the free delivery of clean water to the fountains, A.I. Delvig at the same time expressed an indifferent attitude to the new water pipeline of the urban estate, hinting at the critical mood of the middle urban layers against any, even constructive, initiatives of the authorities[35].

It should be noted that in assessing the quality of water by the middle of the 19th century, an opinion prevailes regarding the necessity of studying not only organoleptic indicators and inorganic compounds detected with chemical methods, but also organic impurities. At the time the water, which did not contain many organic impurities, was thought of as water of sound quality[36].

The growth of water consumption forced the authorities to build and operate in the 1860s–1880s several auxiliary water pipelines to provide certain parts of the city with local spring water. It was Khodynsky (130 thousand buckets), Andreevsky (35 up to 50 thousand buckets) and Sokolnichesky (60 thousand buckets) water pipelines that fed from the same springs. Due to their low capacity, they could not improve the situation with the supply of drinking water drastically [37]. The Sokolnichesky water pipeline, which was part of the old Ekaterininsky water pipeline, also supplied water of low quality, which could be pumped free of charge to private ponds. In 1856, the Commission charging homeowners with fee for using pipeline water even concluded that "due to the sewage in the Sokolnichiy water pipeline, from the Kalanchevsky field to the Neglinnaya river, the homeowners cannot be charged with a special fee for the benefit of the city..."[38]. In 1882, to service the eastern part of the city, the Preobrazhensky water pipeline was built with water from the so-called 'holy' Preobrazhensky well.

In the second half of the 19th century, the experts paid close attention to artesian water. In the period of 1867–71, the mining engineer V.A. Babin tried to drill a deep artesian bore hole in the Yauzsky Boulevard in the hope of receiving up to 500 thousand buckets of water of decent quality every day[39]. However, in 1871, the work was interrupted by breakage of the bore bit of the drilling machine in the bore hole. Having entered a polemic with opponents of his project, with a member of the City Du-

[35] Del'vig A.I. *Moscow Water Pipelines in 1859*. Moscow, 1860, p. 36.

[36] Verzhbdlovskii M.V. *Essays on the History of Water Hygiene in Russia and the USSR (1700s–1960s): Synopsis of the thesis for the degree of a doctor of medical sciences.* Leningrad, 1966, p. 8.

[37] *Water Supply of Moscow in 1779-1902. Mytishchinsky and Other Auxiliary Water Pipelines*. Moscow, 1902, pp. 20–25.

[38] CSA of Moscow, F. 2249, Op. 1, D. 161, L. 66.

[39] *Water supply of Moscow in 1779–1902. Mytishchinsky and Other Auxiliary Water Pipelines*. Moscow, 1902, pp.16–20.

ma, botanist A.N. Petunnikov[40], who considered the water from this bore hole suitable only for watering streets[41], V.A. Babin got permission to continue the work and deliver water through the artesian water pipeline to the city slaughter house. However, the hardness of this natural resource reached 22.5°[42], and subsequently the artesian water pipeline was closed. From 1878 to 1883, the authorities allowed the construction of another 25 small private water pipelines in the city[43], which supplied their owners with water of low quality from the wells and open reservoirs.

The impetus for further development of water supply was given by the energetic activity of the city government, under the control of which the water pipelines were transferred to from the Ministry of Transportation[44] in 1870. The presence of two owners at different water supply facilities in the city did not have the best effect on its efficiency and development prospects. The Ministry of Transportation now had only the highest technical supervision of the installations providing water supply, which was subsequently carried out through the Commission for the supervision of the construction of a new water supply and sanitation system in Moscow[45].

In the 1870s, the urban water supply was subjected to a serious test. The peasants of the village of Bolshie Mytischi gave up a plot of their communal land for ten years to tenants who mined a stone for building a motorway. In view of the threat to destroy the aquifer, the mayor appealed to the governor to ban digging the holes not only at the spring wells, but also throughout the water catchment valley, reasonably if when mining stone from the pits "not only the quality of water in the springs may change, but depletion of water in all the springs may occur"[46]. The work at the wells was suspended, but without finding documentary confirmation of Moscow's rights to this plot of land, the city government was forced to buy it from the local peasants[47], to provide protection to the unique source of water supply.

Under the conditions of the limited number of households connected to the water pipeline, the city's water business flourished. According to the report on the Moscow

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[40] For more details, see: Babin V.A. *Comments on the Resolution of Water Supply Issues in Moscow: Artesian Water from the Moscow Borehole*. St Petersburg, 1882.

[41] Petunnikov A.N. Composition and property of the Moscow waters. *Izvestia of the Moscow City Duma*. Moscow, 1879, Issue 3, p. 22.

[42] Vasil'evskaia O.V. *History of Water Supply of Moscow in Hygienic Treatment: Synopsis of the thesis for the degree of a doctor of medical sciences,* Moscow, 1952, p. 15.

[43] Ozerova N.A. Water supply. Water supply of Moscow in *Moscow. Science and Culture in the Mirror of Centuries. All the Secrets of the Capital; book acquisitions O.A. Zinovieva*. Moscow, AST, 2014, pp. 97–99.

[44] For more details about the transfer, see: CSA of Moscow. F. 179, Op. 60, D. 1.

[45] See: Rerberg I. *A brief Essay on the Activities of the Commission for the Supervision of the construction of a New Water Pipeline and Drainage System in Moscow for 25 years (1889–1914)*. Moscow, 1914.

[46] CSA of Moscow, F. 179, Op. 60, D. 1, L. 322 ob.

[47] See, in particular: CSA of Moscow, F. 179, Op. 51, D. 850.

water pipelines in 1879, about 800 individual horse water carters, about 300 private horse water carters and 414 separate hand-held carters were operating in the city. During the day, each of these carters approached the water distribution points six times on average. In addition, at the same points, 75,700 buckets of water were taken daily by water carriers and individual citizens with manual houseware[48]. Water carters and water carriers remained very important figures in water supply for a long time, which the press repeatedly wrote about, and their morals were painted by famous writers and journalists, including A.P. Chekhov and V.A. Gilyarovsky. Their sketches in the best way characterize the portrait of a water carrier as a self-satisfied, arrogant and a shameless man, who did not fear anyone and understood the dependence of the city dwellers upon his water supplies. Water carriers became the topic of creative work for several Russian artists, for example, V.G. Perov[49].

It should be noted that by the end of the 1870s, most of the water consumed by the city still fell not on the water from the pipelines, but rather on the river and wells. According to the estimates of A.N. Petunnikov, out of 16,103 households, only 175 used water from a water pipeline, consuming an average of 601 buckets of water per day for the households. The remaining households, which accounted for an average of 33 buckets of water from the pipeline, compensated for the shortage of water from polluted rivers and wells[50]. Studies conducted by A.N. Petunnikov allowed to conclude that the river water "is polluted in the city to an extent that raises fear for the impunity of its use". The water from wells and ground water consumed by city dwellers in huge numbers, were recognized harmful[51]. The realization that a significant part of the population was still in the system of traditional water consumption and used very low-quality water, put the issue of the need to cover the whole of Moscow with centralized water supply.

At the turn of the 19th–20th centuries, the population continued to use the water from the wells, despite numerous pieces of evidence of its inadequacy and health risks. Thus, the doctor S.S. Orlov, having studied water samples from 204 city wells, came to a general conclusion about the pollution of water from wells "to an enormous extent"[52]. For comparison, S.S. Orlov studied the quality of water in ten wells in

[48] Sytenko I. *Moscow Water supply. Report on the Moscow water pipelines for the period they were managed by the city from 1872 to 1879 with a description of all structures and with the drawings enclosed*. Moscow, 1879, p. 124.

[49] Pupyrev E.I., Balova O.A. Mytishchinsky water pipeline. How its story was reflected in Russian painting of the 19th century. *Moscow Journal*, 2012, no. 9(261), pp. 70–79.

[50] Petunnikov A.N. Composition and property of the Moscow waters. *Izvestia of the Moscow City Duma*. Moscow, 1879, Issue 3, p. 15.

[51] Ibid, p. 23.

[52] Orlov S.S. *Ground water of Moscow and its Cemeteries: A Comparative Assessment of Ground Water in the Drainage and Non-Drainage Areas. Thesis for the degree of a Doctor of medical sciences*. Moscow, City Printing House, 1905, p. 162.

Moscow cemeteries and came to a paradoxical conclusion that the water in the cemetery wells was cleaner than in the city wells[53]. The hygienists were particularly concerned about the fact that polluted water from the shallow wells could become a source of epidemic diseases such as typhoid fever and cholera[54].

It is worth mentioning that by the end of the 19th century, Russian hygienists, such as F.F. Erismann, A.P. Dobroslavin and I.P. Skvortsov, had done a lot to study the role of water in the spread of diseases, providing evidence of harm from polluted water. At that point, when assessing the quality of water, they determined not only the presence of organic substances and products of their decay in it, but also that of microorganisms[55].

In 1890–93, the Mytishchinsky water pipeline was radically rebuilt to increase the flow of water to the growing city. Initially, it was planned to expand the water catchment area between the villages of Leonov and Bogorodsky in the basin of the Yauza River, but there was a danger that the increased pumping could draw water into the catchment wells, which was polluted with household and industrial effluents from the Yauza River[56]. The prediction for a possible decrease in water quality played an important role in the project to expand the water catchment areas being rejected. Instead, alongside the old lines, a second line of new wells for water catchment, of a larger diameter, was constructed. The supply of water to the city has grown gradually to 3.5 million buckets per day.

The increase in pumping volumes of Mytishchi water gave an unexpected effect, which was expressed in the increase in its hardness. In 1908, a special commission was created that included chemists, doctors, geologists and engineers to investigate the causes of hardness. This phenomenon was originally associated with the penetration of water into the catchment wells from the Jurassic clay layers, and they proposed to solve the problem by raising the level of ground water in the catchment area. Later they came to the opinion that the reason was draining of peat-bogs around the Yauza River[57]. Although pumping of spring water was stabilized at the level of two

[53] Ibid, pp. 154–155.

[54] Sysin A. Essays on sanitation of Moscow. Protection of water, soil and air. *Izvestia of the Moscow City Duma. General department,* 1915, August, p. 25.

[55] Verzhbdlovskii M.V. *Essays on the History of Water Hygiene in Russia and the USSR (1700s–1960s): Synopsis of the thesis for the degree of a doctor of medical sciences.* Leningrad, 1966, p. 14.

[56] Rerberg I. *A brief Essay on the Activities of the Commission for the Supervision of the Construction of a New Water Pipeline and Drainage System in Moscow for 25 years (1889–1914).* Moscow, 1914.

[57] Modern economy of Moscow. Moscow, 1913, pp. 354–355; Ozerov S.A. Mytishchi water and the reasons for strengthening its hardness. Chemical part. *Works of the Commission organized by Moscow city public administration to investigate the reasons for strengthening the hardness of Mytishchi water. Division II. Special articles about works of the Commission. Issue III.* Moscow, 1915.

million buckets per day since 1903, its hardness continued to increase. At the same time, the increase in the salts of iron and manganese in the Mytishchi water was recorded, which formed a black coating on the pipe walls. Water was often made turbid in pipes, which caused complaints from the citizens. The water pipelines had to be flushed with reverse current of water with increased speed, which gave good results. A pilot plant for deironing water was tested at the Mytishchinskaya station in 1915[58].

Since the mid-1890s, the shortage of water was felt again due to population growth, increase in house branches, commissioning in 1898 of the first stage of drainage, and the refusal of the Muscovites "to use several sources of water of dubious quality from ponds, rivers and wells"[59]. A cardinal solution to the problem could only be the use of the resources in the Moskva River, the acceptability of which for the water supply was confirmed in 1886–87 by the studies of the sanitary doctor M.B. Kotsyn, who proposed to pre-purify the river water with sand filters[60].

A large-scale project of the Moskvoretsky water supply was implemented by the city in 1900–12. It envisaged drawing of water in Rublev, upstream the Moskva River, with its further filtration on the so-called slow English filters filled with sand. It was important not to allow the outbreaks of epidemic diseases in Moscow that occurred in 1907–09 in Kiev and St Petersburg, where the intakes of urban water pipelines were located downstream of the drainage[61]. After bringing the water quality to the sanitary standards, it was to be pumped to the Vorobyovy Gory reservoirs and then distributed over the city water supply network across part of the city that was not covered by the Mytishchi water. Subsequently, the water from the Moskva River began to be mixed in the network together with the Mytishchi water.

However, the English sand filters were poorly adapted to the work under the conditions of the Russian climate, so the chief engineer of the water pipelines N.P. Zimin defended the advantage of more compact, economical and high-speed American mechanical filters based on the use of coagulant – aluminum sulphate, also known as alum feather[62]. The hygienists reacted to the idea of N.P. Zimin very cautiously. Thus, in 1899–1902, a special commission under the guidance of the professor of

[58] Khramenkov S.V., Sigin A.P., Sadova N.I., Blagova O.E. *200 years of Moscow Water Supply*. Moscow, 2006, p. 47.

[59] CSA of Moscow, F. 179, Op. 53, D. 114, L. 2.

[60] See: Kotsin M.B *The experience of systematic observations of the fluctuation of the chemical and bacteriological composition of the Moskva River water for 1887–1888: MUDr Dis*. Moscow, 1889.

[61] Davydov A.N. State policy of Russia on protecting the environment from pollution in the context of solving demographic problems in the late 19th – early 20th centuries. *Historical Ecology and Historical Demography. Collection of scientific articles; ed. Yu.A. Polyakov*. Moscow, 2003, p. 269.

[62] See, for example: Zimin, N.P. *New Directions in the Purification of Large Quantities of Water for Urban Water Supply*. Moscow, 1902, as well as numerous statements by N.P. Zimin at the Russian water congresses.

Moscow Imperial University S.F. Bubnov, tested the effectiveness of three types of American mechanical filters when filtering the river water at the experimental filter station. The commission unanimously supported the conclusions of S.F. Bubnov on the unreliability of the American filters and their uselessness "...for large-scale water purification in application to urban water supply"[63], even though it consisted of adherents of the American filters – engineers N.P. Zimin and K.P. Karelskikh. In 1902-06, the work of the commission under a new name was continued to compare the English and the American filters[64]. At a later stage, its experiments served as a starting point to arrange the Commission for monitoring the work of filters in Rublev, and since 1913 – the Commission to monitor drinking water and sources of Moscow municipal water supply, which continuously observed the sanitary condition of the water in the Moskva River[65]. Such control was extremely important under the conditions of acute consumer and industrial pollution not only in all the significant reservoirs of Moscow, but in the Moscow region, overall[66]. For this purpose, a dedicated laboratory was arranged at Rublyovskaya Station.

It should be noted that during the flood of 1904, the English filters showed their inefficiency, and the specialists resorted to water purification according to the American system. Since 1906, the coagulant had been continuously used at Rublyovskaya Station with the careful sanitary control of the water purified by this method[67].

For many years, the city public administration, caring about the state of the water around Rublyovskaya Station, repeatedly raised the issue of a legislative ban on the construction of industrial establishments 25 versts up the Moskva River from the water intakes, however did not receive support from the higher administration in this matter[68]. As a result, in June 1910, the City Duma recognized that "it was necessary to establish permanent and strict sanitary supervision over the Moskva River basin

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[63] Bubnov S.F. *American Mechanical Filters. Sanitary assessment of their work on the results obtained at the filter station in Moscow*. Moscow, 1904, pp. 128–130.

[64] Ignatov N.K. English sand filters set at Rublevsky water-lifting station for cleaning Moskvoretskaya water. 1902–1905. *Review of the activities of the 'Commission for studies of the work of filters and water for the New Moscow water pipeline'*. Moscow, 1908.

[65] For more details, see: Report of the Commission for monitoring of drinking water and sources of Moscow water supply for 1913. Moscow, 1915.

[66] For more details on the pollution of water reservoirs, see: Davydov A.N. The struggle over the environmental consequences of entrepreneurial activity in Moscow industrial region at the beginning of the 20th century in *Bulletin of the Peoples' Friendship University of Russia. Ser.: Russian history*, 2006, no. 1(5), pp. 116–125.

[67] Ozerova N.A. Water supply. Water supply of Moscow in *Moscow. Science and culture in the mirror of centuries. All the secrets of the capital / book acquisitions O.A. Zinovieva*. Moscow, AST, 2014, pp. 103–104.

[68] Davydov A.N. State policy of Russia on protecting the environment from pollution in the context of solving demographic problems in the late 19th – early 20th centuries. *Historical Ecology and Historical Demography. Collection of scientific articles; ed. Yu.A. Polyakov*. Moscow, 2003, p. 273.

above the Rublevsky water-lifting station"[69]. However, the upper reach of the Moskva River was beyond competence of the city public administration; thus, in 1915, a temporary agreement was concluded with the Moscow provincial zemstvo "on joint sanitary supervision around the water basin feeding the Rublevskaya water-lifting station", which was to be effective since the 1st July 1915 until the 1st January 1918[70]. The sanitary doctors of the zemstvo and the city, joining their forces, conducted joint water and sanitary supervision of the Moskva River basin and its confluents.

In the same years, the city public administration also tried to establish a sanitary procedure regulating the work of water carters. In particular, in 1909, the City Duma amended its mandatory resolution "On the procedure for public use of water delivered by urban water structures and on protecting these structures from damage" by adding a paragraph that prohibited the water carters from watering horses from the same buckets that were intended for supplying water to the citizens[71].

Thanks to the Moskvoretsky water supply system, by 1910 the water supply network expanded to 453 versts, and the number of households attached to it increased to 37.8 %[72]. The water pipeline was becoming the most important factor in everyday life of the Muscovites, so any malfunctions in the water networks and the appearance of turbid water caused a violent reaction from both the inhabitants and the authorities. On the 15th July 1913, the Moscow Governor N.L. Murav'ev called on the city public administration to take all measures to ensure the effective supply of the population with water of sound quality, outraged by the fact that in his house "...there was repeatedly dirty water, dark red and black in its colour, completely unfitted for consumption"[73].

Under the influence of centralized water supply, the daily life of the city and the traditional practice of water consumption were transformed. In Moscow, they began to practice sanitary watering of the streets and the greenery, which was unthinkable under the conditions of the previous water shortage. The Moscow drainage system also developed successfully in the presence of sufficient volumes of water, which broke down the centuries-old tradition of citizens to treat water assiduously. One can agree with the conclusion that the new methods of water supply improved the comfort of living and freed the time of citizens for other occupations[74]. At the same time, the new stereotypes of behavior also influenced the urbanization of the city.

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[69] CSA of Moscow, F. 179, Op. 21, D. 2812, L. 21.
[70] CSA of Moscow, F. 179, Op. 21, D. 3420, L. 16.
[71] CSA of Moscow, F. 179, Op. 21, D. 2706, L. 6.
[72] *Water supply and ways to remove sewage in cities of Russia*. Edition of the Office of the chief medical inspector of the Ministry of Internal Affairs. St Petersburg, 1912, pp. 80–81.
[73] CSA of Moscow, F. 60, Op. 9, D. 66, L. 1.
[74] Kos V.V. Water supply of a provincial city at the turn of the centuries (on the example of Tomsk province at the end of the 19th – early 20th centuries). *Bulletin of the Kemerovo State University*, 2013, vol. 1, no. 2, p. 54.

Since 1914, the program to study Moscow's promising sources of water supply had begun, which covered the basins of the Volga and the Oka rivers, as well as several lakes. Along with technical issues, the issue of water quality and its ability to become effectively clean was studied. For such testing, experimental filter stations were built on the Volga River in Savelovo and on the Oka River in Kolomna[75], which during World War I conducted a series of experimental cleaning of the water in the local rivers[76]. These results were used in further development of Moscow water supply in the 1930s.

As a promising source of water supply, the artesian waters were also considered. Thus, upon the instructions of the city public administration, the geologist A.P. Ivanov investigated this issue and concluded that there were considerable reserves of the underground water in Moscow region[77]. At the same time, Moscow's sanitary doctors pointed to the danger of pollution of the artesian aquifer through the deep wells drilled at the turn of the 19th and 20th centuries to lower the level of the ground water during the construction of such large facilities as the Hotel Metropol in Teatralnaya Square, the Polytechnic Museum in Lubyanka Square and several others[78]. Through these wells, not only the polluted ground water was drained into the depths, but also the liquid wastes and sewage could be illegally discharged.

During World War I, the city was supplied with water without interruption, despite the influx of refugees and the wounded. However, in 1916, the water facilities began to experience difficulties in obtaining aluminum sulfate for water treatment during the forthcoming spring flood in 1917. Specialized chemical enterprises of Russia were engaged in defense orders and could not provide the needs of Moscow water supply to the required standard. The city government had to take advantage of the offer of the British firm *Peter Spence & Sons* from Manchester, which agreed to supply 1000 tons of alum feather suitable for its quality and price.

The first 250 tons of the English coagulant were transported by steamships to Scandinavia and from there via Finland were delivered by railway in the spring of 1917 to Kuntsevo, where the cargo was transported to Rublev by cart transport. However, the rest of the alum feather had to be abandoned due to the rise in the cost of transportation and cargo insurance under the conditions of the German submarine warfare that was launched against the Allies. In addition, by the spring of 1917, the

[75] *Moscow, the 20th century. Historical ecology: Archival documents. Issue 1. 1901–1991, compiled by A.N. Davydov*. Moscow, 2000, pp. 95–99, 101–104.

[76] *Works of the Commission on the search for new sources of water supply of Moscow in Moscow Municipal Economy. Water Supply Management*. Moscow, 1927. Issue 5. Purification of the Oka and the Volga waters at experimental filter stations, Ed. Lazarev V.A.

[77] For more details, see: Ivanov A.P. *Artesian Waters in Moscow*. Moscow, 1916.

[78] Khertsov I.R. Sanitary assessment and protection of artesian water in Moscow from pollution in *Artesian Waters of Moscow: Supplying the Population and Industrial Enterprises*. Comp. B.M. Dan'shin, S.L. Korovai, I.R. Khetsrov, V.G. Khimenkov. Ed. N.I. Gushchina. Moscow, 1928, p. 75.

shipment of alum feather was resumed by the traditional suppliers, and additional production was entered at the chemical plant of the City and Zemsky Soyuz[79].

The revolutionary upheavals of 1917 led to the disruptions of forage, horses and water barrels in the markets. The water carters began to abandon Moscow, aggravating the problem with drinking water in the areas not covered by the water supply network. The Muscovites demanded from the city authorities, from the Commissar of the Provisional Government in Moscow N.M. Kishkin, to connect a supply train intended for watering the streets, to deliver water to the population and not to "...leave the citizens to suffer without water..."[80]. The water supply crisis forced the city public administration to accelerate in the summer and autumn of 1917 the construction of another water conduit from Rublev to Vorobyovy Gory and the branches from the city water pipeline to the city outskirts that needed water most badly. Until the autumn of 1917, the Commission to monitor drinking water and Moscow's water supply sources in Rublev carefully supervised proper functioning of the filtering devices and the quality of the drinking water.

The October events of 1917 and the subsequent civil confrontation did not stop, but only slowed down the development of Moscow water supply. In 1920, the activity of the Commission to monitor drinking water and Moscow's water supply sources was resumed, and urgent repair and restoration works were carried out at the water supply facilities. After the installation of filters in Rublev, the volume of water purification increased significantly. As soon as the country stabilized its socio-political situation, the city authorities and the government returned in the early 1920s to the solution of the long-overdue problems to create security sanitary zones with the sources of Moscow water supply, and a while later to the expansion of water supply system based on confirmed sources in the Volga River basin. At the same time, the problem of quality of drinking water was constantly in the focus of attention for the city authorities, specialists in the water supply and drainage sector, as well as the state sanitation inspection of the city of Moscow.

Conclusion

To sum up, it can be concluded that the water supply system of Moscow, having worked its way through the 19th – early 20th, from the gravity water pipeline of the Catherine epoch towards a unified centralized system that included the modernized Mytishchinsky water pipeline with the spring water and the Moskvoretsky water pipeline with purified water from the Moskva River, by the early 20th century satisfied the first priority requirements of the population in clean drinking water. At the

[79] For more details, see: CSA of Moscow, F. 60, Op. 9, D. 344; F.179, Op. 8, D. 3324.

[80] *Moscow, the 20th century. Historical ecology: Archival documents. Issue 2. 1917–1945, compiled by A.N. Davydov*. Moscow: Publishing House of Moscow Main Archive, 2003, pp. 23–24.

same time, it can be stated that during the whole period, the lack of water from the water pipeline was compensated by the city dwellers consuming local spring water, and even to a greater extent – the water of poor quality from dug-wells and open reservoirs. The role of the wells and open water reservoirs in the water supply had steadily declined due to the widespread pollution of river, pond and ground waters.

In case of acute insufficiency of the water supply network, the water carriers and water carters played an important role in water supply, delivering water from the distribution fountains and wells to the households. The number of the household connections to the water supply network was minimal, and it began to grow noticeably only when the Moskvoretsky water pipeline started to operate, which had a serious impact on the transformation of the everyday life and the traditional practice of water use by the Muscovites.

The issues of water quality became a priority during the new construction and reconstruction of water pipelines. The control over the quality of drinking water had become tougher as the hygiene science developed, and because of increased attention on part of the city administration and the city government towards the issues of public health and in the face of severe water pollution and the threat of epidemic diseases spreading.

The search for new sources of water supply, conducted in 1914–17, paved the way for the expansion of Moscow water supply in the Soviet years, and proposals to ban the construction of the enterprises upstream the Moskva River served as a starting point for the creation of sanitary protection zones of Moscow water pipelines, that had started to operate since the 1920s.

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