European Water 58: 465-472, 2017.

Evolution of water supply infrastructures of Thessaloniki city, Hellas, through centuries

S. Yannopoulos[1], A. Kaiafa-Saropoulou[2*], E. Gala-Georgila[3] and E. Eleftheriadou[4]
[1] *School of Rural and Surveying Engineering, Faculty of Engineering, Aristotle University of Thessaloniki, GR 54124 Thessaloniki, Greece*
[2] *School of Architecture, Aristotle University, 54124 Thessaloniki, Greece, Cherianon 7, Kalamaria, GR 55133, Thessaloniki, Greece*
[3] *Delfon 195, GR 54655 Thessaloniki, Greece*
[4] *Department of Environment and Hydroeconomy of Thessaloniki, District of Central Macedonia, 26th Oktovriou 64, GR 54627 Thessaloniki, Greece*
[*] *e-mail: minakasar@gmail.com*

Abstract: Thessaloniki city, in the east core of Thermaic gulf, has been continuously inhabited for about 2330 years. The choice of its founding at this specific location is very much attributed to the high availability of water in the wider region. However, the development of Thessaloniki in a big city and the simultaneous increasing population, created an increased need for water, which could not be covered by the water of the wells. Until the 19th century, water needs were met with cisterns, water channels, fountains and water towers in combination with the wells. Moreover, the city was also equipped with large scale and of high expertise water supply projects, which were exploiting the region's water resources in four different places and were transferring water inside the walls. These water transfer works were associated with water distribution systems, with pipes located beneath roads or following the contour lines. Also, people who lived in the Hellenistic, Roman, Byzantine, Ottoman and newer Hellenic periods gave their own perspective in the problems related to water supply in the city. A review of all these techniques through centuries is presented and commented in this paper.

Key words: Thessaloniki, infrastructures water supply, Hellenistic-Roman-Byzantine-Ottoman and newer Hellenic periods

1. INTRODUCTION

Thessaloniki, was settled in a narrow area between the edge of Hortiatis mountain and the Thermaic Gulf, in a limited area of 250 ha lying between west and east walls, which were developing vertically from the acropolis to the sea. The city had both rich underground aquifers, within the urban grid and good quality water springs in Hortiatis Mountain and the hilly wider region (Figure 1).

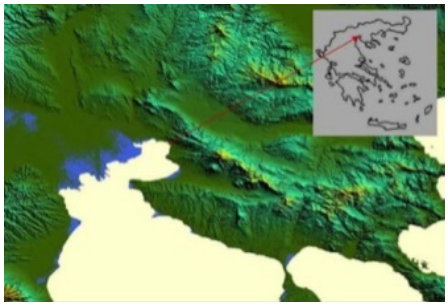

Figure 1. Thessaloniki, map of the whole area

Soon after the foundation of their new city, the residents used to draw water from underground aquifers, by digging wells. Later on, in parallel with the wells, they constructed four aqueducts, according to advanced hydraulic technologies, through which they carried water to cisterns. From

these water end points, pipe networks, located beneath the roads, were branching all over the city. In modern times, after the liberation in 1912, the city extended *extra muros*. Thus, new water supply needs have been emerged, which had to be covered based on new hydro-technological achievements. Particularly, after the great fire of 1917 new water sources have been sought and water supply infrastructures have been reorganized, so as to ensure water sufficiency both for the old city center and for all the new neighborhoods which were rapidly expanding. This paper provides valuable insights into the water supply technologies developed in the city of Thessaloniki.

2. THESSALONIKI: SHORT HISTORICAL REVIEW

Thessaloniki was founded in 315 BC by the King of Macedonia Kassandros, who united 26 small agricultural settlements scattered in Mygdonia field. Very soon, the city became one of the most significant cities of the Macedonian Kingdom. It was founded in a limited area with intense downward gradient from Northeast to Southwest, high elevation and steep inclines in the Upper city and more shallow inclines towards the sea (Yannopoulos *et al*., 2015). Through ages its urban profile has been many times renovated, due both to the increasing population, needs and culture of every era. Moreover, series of catastrophic earthquakes, especially during the 7th century AD, and floods changed the ground level in several points within the walls.

One of the most prominent factors for the foundation of the city in this particular area was the adequate quantity and good quality of the water resources rising in Hortiatis Mountain, nearby. Many of these water quantities were "blocked" in underground aquifers, or often appeared in superfluous streams and currents, that were enriched by rain and surplus water altogether flowed with high velocity, crossing the city and eventually discharging into the sea, inner or outer city walls (Yannopoulos *et al*., 2015). Despite all these man-made renewals and the various physical or human-induced disasters mentioned above, the geomorphology of the area maintained its main features inside the city walls over time (Gala-Georgila, 2015). Furthermore, the Hippodamian grid also maintained in general its original plan through ages (Dimitriadis, 1983), so as the superposed horizontal and vertical streets in many cases remained in approximately the same axis with the older ones lying underneath (Egnatia str., Ag. Dimitriou str., Philippou str.). The abundance of good quality aquifers in specific locations in Hortiatis Mountain, the geomorphology both within the city and in the countryside and the almost constant maintenance of the Hippodamian urban plan through centuries, determined the exact locations of the water sources, the aqueducts' routes, their end-points and the development of water distribution networks.

3. DEVELOPMENT OF THE WATER SUPPLY SYSTEM OF THESSALONIKI

3.1 The Hellenistic and Roman periods

There is no doubt that hand-dug wells covered the water demands just after the city's establishment, in the end of 4th century BC. A large number of them have been found in house plans, public places, or even cemeteries, varied in formation of shafts, well-head configuration and size. They were usually stained of circular section, while during the roman period, stone masonry was usually combined with the widespread use of scattered parts of bricks and tiles sometimes all bonded with lime mortar construction. Up till now two square stone made wells of roman times have been recorded in the town. The rectangular shape has been rarely preferred in Byzantine times. On the contrary in Ottoman period all the wells were of circular cross section (Kaiafa-Saropoulou, 2014a).

Besides the wells that were in abundance, the city of Thessaloniki, was equipped with more than one water technical project, which had different starting points, Hortiatis, Retziki, Lebet and Anthemounta valley (Galatista) (Gala-Georgila, 2015; Tamiolakis, 1985) (Figure 2). The exact construction dates of these technical water transporting projects remains a nebulous matter, because of the piecemeal architectural remaining. However, bearing in mind that the construction of an

aqueduct was a huge task, usually financed by the Emperor, it is very possible that each of the four aqueducts of Thessaloniki was part of intense building regenerations that took place at the turn of 1st century BC, in 2nd century AD or much later at the end of 3rd century AD.

Despite the very few Hellenistic data of a pressurised piping system within the city, the existence of at least one aqueduct before the Roman period is almost certain. It was supplying water to houses, fountains and public baths, like the one of the 2nd century BC that was located in the NE corner of the city's Agora. During roman period, when the city has been embellished with splendid buildings, increasing water needs are related to the extended use of public baths and latrines, which were playing a major role in the life style and presupposed continuous water flow. In the beginning of the 4th century AC, Galerius renewed the city by renovating old buildings or constructing new ones, equipping them with advanced hydraulic infrastructure which also expanded all over the urban grid.

Figure 2. Thessaloniki, aqueducts 1. Hortiatis Aqueduct (springs), 2. Retziki Aqueduct (springs), 3. Lebet Aqueduct (springs) 4. Kalamaria Aqueduct (the area SE of the city, remains).

Springs in Hortiatis, nearby the modern village, 600-900 a.s.l., provided the consuming residents of the ancient city with good quality waters at least since Roman era, maybe since 2nd century AD, being probably part of the Antonine's fiscal policy (Kaiafa-Saropoulou, 2014b). Water was collected through the qanat of Agia Paraskevi, consisted of two or more underground galleries. Nowadays only its middle Byzantine phase and the renovation of Mourat II are visible. Due to the addition and restorations through centuries in order keep a continuous function until the year 1975, almost no evidence of Roman times has been found, except few remains in the lower part of the foundation of the later Ottoman, still standing, water-bridge, the current form of which belongs to the later years of Byzantine and mainly to the Ottoman period. It is very difficult to observe the routing of the Roman phase of Hortiatis aqueduct, though it is unlikely to follow the same way with the Byzantine and Ottoman water-channel, being about 22 km long till the central end point, located probably north of the Byzantine Acropolis (Eptapyrgion) (Gala-Georgila, 2015).

Retziki springs, situated further North, near the church of Agia Triada (Pefka), seem to be a second water collection point, supplying the western side of the city (Figure 2). In the east wider area, at higher level, water sources were also used to enrich the lower springs through qanat galleries. Unfortunately, the aqueduct remains over there are so few that neither its construction and its route nor the duration of its function can be clarified. It is assumed though that a water transfer project starting from Retziki springs, 350 m a.s.l., was supplying the city even before 2nd century BC. Its presence is indirectly attested in a 2nd century AD inscription, referring to the repairing of a water transporting work being in a place name "Altias" (Kaiafa-Saropoulou, 2014b). Byzantine archaeological data suggest that its length reached approximately 8 km and its end point is located in the grove of Sykies, near a modern water tank of EYATH S.A. From there the routing of the water till the walls of the city is uncertain. There are two possible alignments, the first of which ended up in the SW part of the Byzantine Acropolis and entered the city from a small gate of the north wall. According to a second view the water conduit met the routing of the third aqueduct of the city, known as Lebet aqueduct. Finally, the remains of an aqueduct bridge that crossed

Xiropotamos torrent, very close to the water sources in Retziki, belong to the 15th -16th century AD, as a part of a major renovation (Gala-Georgila, 2015; Tamiolakis, 1985).

The third aqueduct was transferring water from springs located in the area near the present village Eukarpia (Figure 2), which were enriched through qanat, whose exact starting point is not known (Gala-Georgila, 2015). Parts of an open flow aqueduct channel have been found in several spots in the area of Polichni and Stavroupoli, which certify more than one construction phases; the earliest of which are Roman, yet no further information is available so as to have a more exact dating. That is a stone built conduit rectangular in section, covered by stone slabs and a consistent slope of 2‰. The end point was probably located in a cistern in the area of Kallithea, from where the water was branched in the west part of the city.

Moving on, the Roman Emperor Galerius (turn of the 3rd century AD) renovated and improved the hydraulic infrastructures all over the urban grid. The aqueduct which has been built then, simultaneously with the construction of the Palace complex, probably ensured its continuous water supply. Parts of a vaulted stone made water conduit with manholes on its arch, which have been revealed in Toumba, in Pilaia, in the area of American Farm School and at various points in Thermi village, prove the presence of an important and quite extensive aqueduct which laid in Kalamaria valley, southeast of the city of Thessaloniki, in an area where fissured rock aquifers and karstic aquifer discharge ground water through springs. Its beginning is placed either in the Anthemountas valley or near the Thermi dam and the endpoint is located in Thessaloniki, about 150 meters north of Kalamaria's gate in the east city walls, in the area of Evaggelistria (Gala-Georgila, 2015).

The water transfer projects mentioned above were combined with water distribution networks, which were scattered throughout the city. Both Hellenistic and Roman urban grid was undoubtedly favorable to the development of a well-organized network of water distribution. That was consisting mainly of clay pipes with well proofed joints, and more rarely of lead pipes, supplying individual consumers, public buildings and a large number of fountains.

3.2 The Byzantine period

The residency of Constantine the Great in the city during 320-323 AD resulted in the construction of numerous hydraulic infrastructure works. The city flourished over the next two centuries and the population increased at a high pace. Thus, new public buildings and luxurious private residences led to increased demand for fresh water, which has been covered by water distribution infrastructures (Karydas, 2009). Furthermore, a series of catastrophic earthquakes during the first decades of the 7th century severely damaged the city, resulting in the destruction of public buildings, walls and infrastructures. The constant need of fresh water led to the continuous renewal of the city's water distribution network. Building of large and important cisterns seems to have occurred constantly with reservoirs being found dated to the 7th until 14th centuries. At the same time, successive repair work is evident in cisterns, which indicates that they were abandoned only in case of complete destruction (Gala-Georgila, 2015).

The necessity for water storage, led to the conversion into reservoirs of several important buildings from the Roman and Early Byzantine period, such as the Cryptoporticus in the Roman Forum, the monumental vestibule of the Octagon in the Galerian Complex (Athanassiou *et al*., 2004) and the utilisation of the wall in the Roman Acropolis near the Trigonion area (Marki and Konstantinidou, 2005). The transport of water inside the city was achieved by using masonry stone covered conduits and terracotta pipes with an inner diameter of 10-13cm. The masonry conduits were usually constructed on top of a stable foundation. The side walls were covered with hydraulic mortar, while the bottom was covered using ceramic tiles, stones or slate.

Both the end points of the external aqueducts and the terrain morphology show that the distribution of the water started at the highest points of the city. Water was transported by open flow conduits. Closed terracotta pipes, functioning under pressure, were only utilised to supply water to specific destinations from water towers or reservoirs at a close distance. The flow of water on the highlands, where the gradients can be extremely high in certain parts, was achieved using conduits following the contours of the terrain. The neighbourhoods towards the sea were fed using conduit

systems arranged 'vertically' following the streets that were perpendicular to the shoreline. Reservoirs were usually located at the top of these distribution lines. (Gala-Georgila, 2015). Gradually as the city weakened during the last decades of the 14th century, the water distribution system fell into disrepair.

3.3 The Ottoman period

The city of Thessaloniki was conquered by the Ottomans in 1430. Small scale changes and repairs to the water supply system seem to be occurred immediately after the fall of the city. The Hortiatis aqueduct was repaired and twenty new public fountains were constructed.

During the 16th century the dispersion of the city's population had an important effect on the organisation of the water distribution system, which was very much improved and extended. The incoming water supply was carried by two aqueducts: The Hortiatis aqueduct and the aqueduct of Lembet or Yeni Su, which was constructed by uniting the two earlier byzantine aqueducts of Eukarpia and Retziki (Gala-Georgila, 2015). The main water structures which made up the Ottoman water distribution system were the maksems or taksims and the water towers or suterazisi. The maksems above or below ground were either domed or vaulted buildings containing water tanks with a discharge measuring system or simpler constructions (Dimitriadis, 1983). Known as su terazisi, the water towers had a cistern at the summit from which the water flowed into distribution pipes. These structures maintained water pressure and improved water distribution to districts with shallow inclines towards the sea (Gala-Georgila, 2015). The water was conveyed using masonry conduits and terracotta pipes as in the previous periods. The public fountains all over the neighborhoods played a major role.

Over the next few centuries, Thessaloniki experienced great growth, thus the need for fresh water was high, especially when considering of the great number of public baths, up to 300. Water needs had been usually ensured by drilling wells, up to 3000, according to the traveller Evlia Tselempi, or building many fountains through the city. According to him, Thessaloniki contained 300 public baths. During the 19th century the land wall of the city was torn down, a new port was constructed and the infrastructure was modernised. In order to modernise the water distribution system the 'Ottoman Water Company of Thessaloniki' was founded. The new system utilised pumps and was constructed between the end of the 19th century and the beginning of the 20th century (Tamiolakis, 1985).

3.4 The period from 1912 (independence) to 1939

After the city's liberation from the Ottomans in 1912, the Municipality of Thessaloniki took over the water supply of the city. The three aqueducts of Hortiatis, Retziki and Lebet came to the ownership of the Municipality. Almost immediately, Municipality launched a program of maintenance, repair and improvement of these aqueducts and it took care for their proper operation and exploitation and at the same time, Municipality drilled many boreholes within the city area.

The destruction of the water supply network due to the fire of 1917, the reception of thousands of refugees in 1922 and the rapid expansion of the city outside the walls aggravated the problems of water supply of the city. In order to address this situation, Municipality drilled new boreholes and constructed pumping stations at Rysio, Kadirli (Kalamaria), Papafi, Platanos, etc. In 1926, the municipality replaced the old pipes of water supply, and at the same time expanded and repaired the water supply network of the city. During the period 1915-1939, the Municipality built 18 water tanks in various areas of the city. The purpose of these tanks was primarily to ensure the necessary pressure in the water network and less in storage, since the volume of water that could store each one of them was relative small (Tamiolakis, 1985).

In order to meet the needs, municipality bought water from the private Turkish-Belgian company "Compagnie Ottomane des Eaux de Salonique".

In the period of 1922 – 1930, significant interventions and major infrastructure projects were made in the city. Due to the implementation of the new town planning, significant network pipes

that passed through private plots, had to be removed and new pipes had to be constructed in the limits of the new roads of the city. However, the urban water distribution network of the city was not constructed as a whole, but in order to meet the water needs of the citizens, it was extended according to the extension of the city. Thus, it was proven the very soon that the network has become inadequate to meet water supply needs because of inadequate sections of the pipelines. Throughout this period, great efforts were made to improve the water supply system with the maintenance of aqueducts, the conduits replacements, the drilling of new boreholes and the construction of reservoirs.

3.5 The water supply system of Thessaloniki after 1939

In 1939, with its establishment, Thessaloniki Water Supply Organization (OYTH) received the water works, which in general (mainly these of Municipality of Thessaloniki) were not in very good condition, since they had not been constructed according to a single plan, but occasionally with the main purpose to meet the current needs of residents. In this way, OYTH confronted significant difficulties in water supply of the city. This situation became hardest with the start of World War II.

In 1949, the conditions became even more difficult with the increase of population due to internal migration and defaults on water bills by users due to the economic impoverishment of the population. From the early 1950s until 1974, the focus was on ensuring the required quantities of water, since the functioning of the urban water distribution network showed satisfactory operation.

The administration of OYTH decided the construction of the pump station at Kalochori and many boreholes were drilled in the wider area, expanding the abstraction of water in the plain of Sindos area, while the aqueduct of Nares in the region of Galikos River was completed. In 1974, it was decided the development of Aravissos sources and of Aliakmonas project and the planning of the urban water distribution network. After the completion of the plans concerning the basic water works, OYTH began the gradual implementation of the construction of reservoirs and major conductors of the water supply network, both to the western and the eastern areas of the city.

Nowadays, according to the contract of 27.7.2001 with the Greek State, EYATH S.A owns or manages facilities which include: a) water abstraction works, b) external aqueducts, boreholes and pipelines, c) pumping stations and tanks and d) the distribution network comprised of pipelines and water meters. EYATH S.A. uses the karst system of aquifers in the Paiko Mountain to supply water to Thessaloniki. Water is abstracted from the Aravissos springs from two natural supply shafts, a spring fitted with a pump and 11 water boreholes which pump water via connecting pipes to the Aravissos aqueduct. The quantity of water obtained from the Aravissos springs ranges from 65,000 m^3/d to 130,000 m^3/d, depending to a large degree on snowfall and rainfall recorded every year (https://www.eyath.gr/).

Also, water is abstracted from the Aliakmonas River in the area known as Varvares around 40 km from the river delta. Water is diverted via a 50 km long free-flowing channel to the Axios River where it reaches the water treatment plant (known as the refinery). Subsequently, the clean drinking water is directed to 75,000 m^3 storage tanks and is distributed via a network of pipes 36 km long to existing water supply tanks at Diavata, Evosmos, Polichni, Neapoli, Vlatades, Toumba and Kalamaria, as well as the Industrial Area of Thessaloniki (Sindos). In the wider area of Axios River (Gefyra, Nea Halkidona, Eleousa, and Agios Athanasios) there are a total of 46 boreholes with ability of pumping around 70,000 m^3/d of water. In case of increased water demand, there are 26 boreholes stand-by in the Kalochori area with ability of pumping around 30,000 m^3/d. From the bed of Galikos River (Narres area) water is abstracted via 3 water collection shafts. The ability of Narres area to collect water varies from 5,000 m^3/d to 25,000 m^3/d depending on rainfall and snowfall recorded each year. The Narres aqueduct is currently out of use and is on stand-by. Moreover, the Agia Paraskevi springs at Hortiatis are used to provide additional water to the Hortiatis Municipal District and as a back up to supply water to the Georgios Papanikolaou Hospital.

Prior to consumption, water is submitted to treatment in the Refinery (Thessaloniki Water Treatment Facility), which lies 2 km north of the Sindos Industrial Area close to the Thessaloniki –

Edessa National Road. EYATH S.A. is the owner of the facilities, but it has outsourced running to a third party and supervises how the facilities are run, by sending expert staff from the relevant company division. At present the facilities can treat 150,000 m^3/d and in the future (after the complete integration of plans and works) will reach 600,000 m^3/d (https://www.eyath.gr/). The total water needs come from Aliakmonas River, in a percentage of 50%, from Aravissos springs, 29% and from boreholes, 21%. The average water needs of the city amount to 250,000 m^3/d while the maximum needs (during summer) reach 290,000 m^3/d. EYATH S.A. operates and maintains 34 pumping stations and 21 reservoirs of water storage for the transmission and distribution of drinking water in the Urban Agglomeration of Thessaloniki. The total length of the pipes of the water distribution network is approximately 1,500 km.

4. AUTHORITIES OF WATER SUPPLY MANAGEMENT OF THE CITY WITH TIME

After the liberation from the Ottomans in 1912, the Municipality of Thessaloniki took over the water supply of the city. In 1917, French engineers officers constructed the "Aqueduct of Harilaou" which belonged to the "First Thessaloniki Building Company S.A." This aqueduct functioned with the one of Municipality of Thessaloniki, at the same time. In 1975, the former Thessaloniki Water Supply Organization (OYTH) purchased this aqueduct.

Until 1929, the private Turkish-Belgian “Compagnie Ottomane des Eaux de Salonique” ensured the water supply of the city, in cooperation with the Municipality of Thessaloniki, which had as purpose of providing water at the central part of the city. This company was established in 1888 by entrepreneur Nemlizade Hamdi Efendi with Belgian funds. In October 1929, the company was sold, without the consent of the Greek State in the international company "Energie Industriel", based in Paris and renamed as "Société de Distribution des eaux de Thessalonique".

In 1939, the Thessaloniki Water Supply Organization (OYTH) was founded by the obligatory laws 1563/1939 and 2318/1940. All the rights of the Greek public and of the Municipality of Thessaloniki by concession and of the "Société de Distribution des eaux de Thessalonique" came to the ownership of the OYTH.

In 1997, the two organizations of the city namely the Thessaloniki Water Supply Organization and the Thessaloniki Sewerage Organization converted into anonymous societies (PD 156/1997 and 157/1997) and later, in 1998, the Thessaloniki Water Supply & Sewerage Co. S.A. (EYATH S.A.) was funded from the merger of Thessaloniki Water Supply Organization S.A. (OYTH S.A.) and Thessaloniki Sewerage Organization S.A. (OATH S.A.) (Law 2651/3.11.1998). Its aim is the water supply and water sewerage or other similar services of its area under jurisdiction and beyond, in the frame of integrated use of water resources. The area of jurisdiction is the same as the one of OYTH S.A. and OATH S.A., with the addition of the industrial area of Thessaloniki. EYATH S.A. is responsible for a) water supply of Thessaloniki urban area and b) the collection and conveyance of wastewater to the Wastewater Treatment Plants and their disposal (Yannopoulos *et al*., 2015).

EYATH S.A. is listed on the Athens Stock Exchange. Pursuant to Article 22 of Law 2937/26.7.2001, when the company was listed, the majority of EYATH S.A.’s assets were transferred to a newly established body governed by public law called EYATH Fixed Assets free of consideration. Under a 30-year contract signed on 27.7.2001 by the Greek State, EYATH Fixed Assets and EYATH S.A., were given an exclusive right to provide water supply and sewerage services within its geographical remit. Under that same contract EYATH Fixed Assets was obliged to provide EYATH S.A. with the necessary quantities of water for a fee to meet its consumers’ needs, and EYATH S.A. was obliged to ensure the rational use of the water sold and make concerted efforts to ensure a reduction in leaks and water losses as much as possible, by improving and rebuilding the water supply network. The activity of EYATH extends on Urban Agglomeration of Thessaloniki and includes (partially or entirely) the municipalities of Thessaloniki and the Industrial Area of Thessaloniki (Industrial Zone I) in Sindos. EYATH S.A. is responsible for both the external and the internal network of this entire region.

5. EPILOGUE

The observations about water supply technology in the city of Thessaloniki carried out in this study are based on data available from various disciplines including archaeology, history, literature, geology and hydraulic engineering. In order to get a general, final insight into the water supply development of Thessaloniki since its foundation at the end of 4th century BC, it is important to point out a series of factors, which determined the water adequacy of the city ensured by the presence of big water transfer projects and water supply infrastructures. These factors are the location of the city and the urban plan, the physical configuration of the urban area, the ground level alterations due to natural disasters or human actions, the landscape geography, in combination with the rich aquifers beneath the urban grid between the walls, and the rich water sources in specific positions in the wider hilly area. Apart from them, other crucial factors were the rapid development of Thessaloniki and the simultaneous increasing population, which created an increased need for water.

Thessaloniki was grown according to the Hippodamian plan and was defined by walls with almost steady course both in Roman, Byzantine and Ottoman period. The fact that this urban plan was generally remained through centuries without great alterations was a determining factor for the development of the water supply network within the city since ancient times. Especially as for the Byzantine era, in the Upper city water conduits were laying out following the contour lines of the hill slopes. In contrast, the supply of the inhabited zones towards the south was achieved with subterranean water channel networks laid out along the squared road-grid.

The presence of the rich aquifer in the area is mainly responsible for the large number of hand dug wells, which had an extremely important role during both antiquity, in Byzantine era and especially in Ottoman period, despite the fact that they were composed with urban distribution networks and supplemented by technical works of great scale and high level technology. From all that has been mentioned above four big hydraulic projects are evident in the city, since the Roman era, which have been resulted from thoughtful planning and organised workmanship. The presence of more than one aqueduct, which probably were supplying the city, is unique in Macedonia and was associated with the city's gradual urban expansion, which was a result both of the population increase and the changes of the lifestyle through ages. They were all ambitious projects, renovated many times, in order to achieve continued functioning. All projects originated from the upper, NW part of Thessaloniki, from where branched pipes were supplying the whole city through cisterns or public fountains in central locations. Their existence provides a clear demonstration of the high level of hydraulic engineering expertise of the engineers.

REFERENCES

Athanassiou, F., Malama, V., Miza, M. and Sarantidou, M. (2004) The Construction Phases of the «Octagon» of Galerius' Palace Complex in Thessaloniki, AEMTH 18, 239-254 (in Greek).

Dimitriadis, V. (1983) Topography of Thessaloniki during the Ottoman era, from 1430 to 1912. Society of Macedonian Studies, Thessaloniki (in Greek).

Gala-Georgila, E. (2015) Waterways and Organization of Space in Thessaloniki during the Middle and Late Byzantine periods. Doctoral Dissertation, Aristotle University of Thessaloniki (in Greek).

Kaiafa-Saropoulou, A. (2014a) Supplying water in Hellenistic and Roman Macedonia: the art of the wells. 1st IWA Regional Symposium on Water, Wastewater and Environment: Traditions and Culture. Patras, Greece: 557-568.

Kaiafa-Saropoulou, G. A. (2014b) Water management and sanitation technologies in Hellenistic and Roman Thessaloniki. In 10th International Hydrogeological congress, Vol. 1: 277-286. Thessaloniki.

Karydas, N. (2009) Early Christian houses with triclinium in Thessaloniki - Part II: ten years after, AEMTH Twenty Years, 127-141, Thessaloniki (in Greek).

Marki, E. and Konstantinidou, K. (2005) The fortifying Wall of the White Tower and other Fortifications in Thessaloniki, AEMTH 19, 211-220 (in Greek).

Tamiolakis, G. (1985) The History of Water Supply of Thessaloniki. University Studio Press, Thessaloniki (in Greek).

Vacalopoulos, A. (1983) History of Thessaloniki 316 B.C.-1983, Thessaloniki (in Greek).

Yannopoulos, S., Kaiafa-Saropoulou, A., Angelakis, A.N. (2015). Evolution of Sewage Management of Thessaloniki City, Hellas. 3rd National Joint Conference HHA-EEDYP-NSS, December 10-12, 2015, Athens, Greece, pp. 583-598 (in Greek).