Drinking water supply techniques.

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During the Roman era, Tunisia knew a long period of urban development. Carthage which was one of the five most important cities of the Mediterranean, was supplied through transfers from Soukra's ground water and tanks. An exceptional drought lasted from 123 to 128 causing the drying up of the region's water resources. This drought showed the necessity to look for water far away from the city and to bring it to Carthage.

In the II nd century, during Hadrian's era, waters coming from Zaghouan and Jouggar mountains were caught and brought via a 132-kilometer long aqueduct (with several branches) to the Maâlga tanks which is a 25 000 –metre water reservoir on the hill of Carthage. Springs had a variable flow rate with a minimum falling below 5000 m3/day and a maximum reaching 25000 m3/jour. Private tanks were necessary for districts which level was higher than Maâlga.

The city of Hadrumete (Sousse), the second city after Carthage, received only 150m3 per day via a 4-kilometer long underground pipeline which was supplied via a drainage in wadi Kharroub ground waters. The necessary support was supplied through brackish water wells and tanks.

The city of Thysdrus (El Jem) is located in an area where water resources were even more scarce. Tanks were very widely used. Wells supplied an even worse water quality when compared with the wells of Hadrumete. Romans tried to catch deep ground waters located 13 kilometers away from the city (in the north western part) through an underground aqueduct going under the hill, which deepest point is located at more than 15 m. The quantity supplied daily to public distribution was about 200 m3/day of a rather sulphated water.

The city of Suffetula (Sbeitla), on the other hand, was supplied through natural springs which flow exceeded 10. 000 m3/day caught and brought to the city and gardens via an aqueduct which remains are still visible today over the Sbeitla river.

Other villages were supplied with spring waters brought via aqueducts: Simithu (Chemtou). Maktaris (Makthar), Zama (Jama), Sufès (Sbiba), Cillum (Kasserine), Thuburbo Minus (Tebourba), Hippo Diarrhytus (Bizerte) and other less important places.

Other villages were supplied with river floods which are directed towards tanks. Some villages, located over springs, used to catch water and to bring it back up into high structures.

In the absence of such resources, water needs were met using wells and tanks.

All these facilities which had been operational up till the Arab conquest were gradually discarded. Nonetheless, the Aghlabide dynasty spared no effort to conserve old structures, it also spent efforts to provide its capital, Kairouan, with Jebel Chérichira waters via a 35-kilometers long aqueduct and huge reservoirs called the Aghlabide basins where waters coming from Oued Merguellil floods are stocked.

As for Zaghouan's aqueduct, it knew ups and downs, cut by Vandals than Arabs, it was restored during the Xth century and provided with a diversion channel towards Tunis in the XIIIth century.

After the Hafside era (XIII$_{th}$-XVI$_{th}$ centuries), the aqueduct maintenance was abandoned and then stopped to be operational. Three years later, in 1852, Sadok Bey ordered French engineers to restore it. Ground and underground parts of the channel were restored and the parts over arcades were replaced by cast iron ducts. Captures were

partially put again in working order. Reparation works lasted about ten years and were ended up by building the Sidi-Abdallah reservoir with a 3.700 m3/day-capacity. In 1861, the waters of Zaghouan and Joggar came back to Tunis and contributed to the improvement of the inhabitants' everyday life.
This reservoir was the only important structure in Tunisia in 1880. Other cities were supplied as follows:
Sousse, through bad quality wells and storm water tanks, Kairouan, through the Aghlabide basins and "Bir Barouta" well which is equipped with a camel-operated noria, Sfax, via storm water tanks and basins which received the excess water of Agareb wadi.
As for other cities and villages, the supply was secured through wells and tanks without any public distribution structure.
In 1880 and 1914, as the supply of Tunis was temporary secured, the effort was focused on other large cities :
Bizerte benefited from a 13-kilometer pipeline to bring the waters of Bou Ras spring with a flow rate reaching 800 m3/day (1895).
Sfax was supplied via a 175-kilometer cast iron pipeline bringing waters from Sbeitla with a daily flow rate of 8000 m3/day (1914).
Bou Hafna waters were brought to Sousse via a 125-kilometer pipeline registering a flow rate of 2500 m3/day (1905).
The supply of Tunis was also improved by branch-pipes on the Zaghouan aqueduct to provide some northern cities with adduction networks.
After 1914, the drought and the consumption increase within cities brought about serious water shortages in Tunis, Sousse and Bizerte.

The overall development of cities caused the extension of public water distribution for ever-growing cities.
In Tunis, trying to meet the increasing demand, the flow rate passed from 6.000 m_3/day to 70.000 m_3/day. This increase was made possible thanks to the opening of the dam over wadi Kébir (with a maximum capacity of 26 million cubic meters giving, in a regular year, 25.000 m_3/day) and to the developing catchment of underground waters in Khlédia, Jouggar, wadi Kébir and Manouba.
In Sousse, the flow rate passed from 2.500 to 7.000 m3/day thanks to the opening of new catchments in Bou Hafna. Sousse shared this flow rate with the Sahel-northern cities.
In Bizerte, several cathments carried out over the northern shore of Bizerte lake in wadi Graâ and El Hamila and the development of Aïn Bou Ras' catchments made it possible to raise the distributed volume to more than 5.000 m3/day.
As soon as1911, the first chlorine sterilization station was installed over the water flume near Bir Mcherga train station, but due to inaccurate processes and equipments, the used reagent was badly measured. This station was replaced, in 1924, by a more reliable facility
Nonetheless, all these works were not enough to meet the increasing water demands because of an ever-growing urban population. 1956 was the start of the mobilization and the exploitation of surface waters and the building of several dams((Béni Metir, Mellègue, Laroussia, Kasseb, Sidi Salem...), adduction pipes (Joumine-Medjerda, Belli-Sahel-Sfax,...) and free-end channels (Medjerda Cap-Bon channel).

Modern stations of drinking water processing were set up (Béni Metir, Ghdir El Golla I and II, Joumine, Bizerte and Belli, totalling 7 m3/s in 1991) and a desalination plant for brackish waters by reverse osmosis was opened in Kerkennah with a flow rate of 4.000 m3/day (1983).

At the same time, the modernization and extension of water distribution networks were all over the Tunisian territory. Rural areas were provided with branched networks and cities with mesh networks reaching, in 1991, a general service rate of 72%. The total distributed volume passed from 24 million cubic meters in 1956 to 196 million cubic meters in 1991, whereas the total population in Tunisia passed from 3,8 millions to 8,2 millions during the same time period.

Concerning the calculation of pressure loss within pipes, the supply of drinking water went through the old empiric formulas (such as Prony (1803), Dupult, Darcy, Lévy, Kutter, Flamant...), to reach modern expressions (Poiseuille, Blasius, Prandtl-Von Karman, Nikuradse, Colebrook (1939)...), which were theoretically or experimentally justified using the theory of fluid mechanics.

Several calculation methods for mesh networks were also used : the experimental analogy method (hydraulic or pneumatic analogy and electric analogy), stepwise refinement graphic and digital methods (Hardy-Cross, 1936).

With the event of calculators and digital methods, modern software using computers are being developed.