UNCONVENTIONAL WATER RESOURCES

By Andreas N. Angelakis* and Georgios Tsompanoglou**

Conventional water resources include rainfall and snowmelt, captured in reservoirs behind dams, storage reservoirs, and flowing in rivers, and groundwater resulting from the infiltration and rainwater and melting snow. Traditionally, these water sources have been used for the development of civilization. However, with increasing world population and the effects of climate change, serious water resource shortages have and are continuing to occur in many parts of the world. Thus, more attention is now being focused on the potential utilization of unconventional water resources (Angelakis, 2018). The principal unconventional water resources are:

(a) Wastewater. Properly and reliably treated, wastewater is one of the most important unconventional water resources, which can be used in a number of different applications, including potable reuse with further treatment. Worldwide, at present, the main use of treated wastewater is for agricultural irrigation. One of the main advantages of using treated wastewater is that it is a relatively reliable source and less affected by short-term climatic impacts. In addition, the use of treated wastewater has both economic and environmental benefits. However, the reuse of treated wastewater continues to be viewed with mistrust, related to the lack of relevant legislation and the difficulty of acceptance by users for obvious reasons. In the international environment, Europe lags significantly behind due to the relevant legislation in force since 1991 and the central and northern countries, which have a high availability of natural water resources. In southern European countries, treated effluents are mainly reused for irrigation, led by Cyprus and

Malta. Leading countries in water reuse worldwide are Qatar, Kuwait, Israel and Singapore.

(b) Sea or Brackish Water. Water for all domestic uses can be obtained by the desalination of sea or brackish water, to removing salts and other harmful constituents. A variety of thermal and mechanical technologies are currently available. The main advantage of desalination is the availability of endless sources of water (sea and brackish water), which are not dependent on climate or weather. Also, by combining desalination technologies with renewable energy sources, the cost of desalination can be reduced significantly, especially where the source water brackish water. In Crete, for example, there are many remarkable coastal brackish springs, such as *Georgioupolis*, Bali, Almyros Heraklion and Almyros Agios Nikolaos.

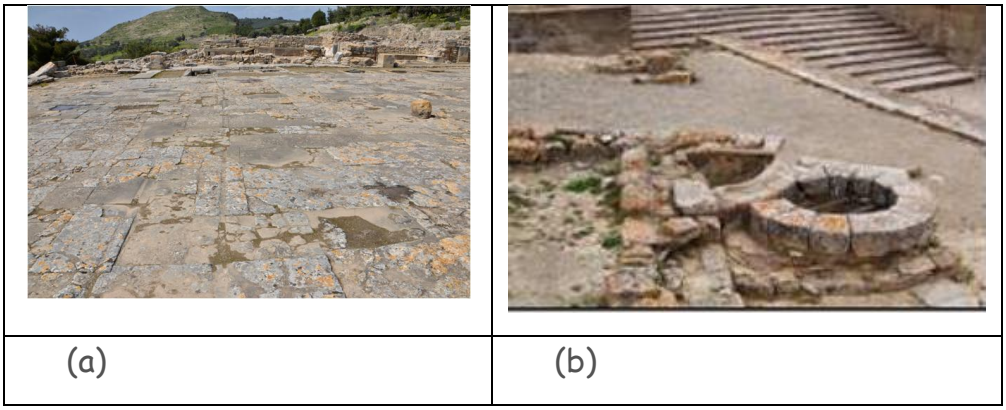
Desalination technologies, which have developed very quickly, contribute significantly to ensuring the sustainability of water resources worldwide. Also, there are several other innovations that can further reduce energy consumption and therefore reduce costs and increase their sustainability. Thus, worldwide, the desalination capacity of sea and brackish water has continued to increase steadily since the beginning of this century,.

(c) Rainwater. The collection, storage, and treatment of rainwater has been a tradition for millennia in Crete and other Mediterranean countries. One of the most characteristic examples is in Minoan Phaistos (Figure 1).

Today it is still used throughout the year, for irrigation purposes during the growing season. It is a process especially useful in arid regions, where there is no water supply network or a private water harvesting project (well or borehole) that covers the needs.

(d) Greywater. Greywater is wastewater generated from homes, after the use of drinking water in the, shower, washbasin, washing machine, and kitchen, but

without wastewater from toilets, often identifies as blackwater. Separate plumbing for the toilets is needed if greywater is to be reused. After undergoing relatively low-cost treatment treated greywater can be used for garden irrigation and in toilet cisterns, resulting in a saving of 30% of a household's water supply. In the city of Heraklion, a residence could be built for the Regional Governor or the Mayor, which, could include a greywater system on a pilot basis. Such a systrm would serve as a model and example for the residents of Crete.



(a) (b)

Figure 1. Water supply system of the palace of Phaistos: (a) an open courtyard for the collection of rainwater, from where it was diverted to smaller tanks. and (b) a special tank with coarse sand filter, which was used to purify water before it was stored in the main tank.

(e) Agricultural Drainage Water. Generally, agricultural drainage water is defined as any water left over from one irrigated crop that is not used to irrigate another crop. In most cases agricultural drainage water can be used for the irrigation of another agricultural crop, instead of being discharged to the sea, or in a river, lake, sewerage system or any other place, as a liquid waste. However, as irrigation water water flows through the soil and drainage network, it is

contaminated by salts, chemicals and other pollutants such as pesticides and, therefore, must generally be treated before being reused.

(f) Recharged Groundwater. Recharged groundwater is surplus surface water introduced into a groundwater aquifer for later use. Artificial enrichment (or recharge) is an effective anthropogenic technique that can be used to replenish underground aquifers. Both surface spreading basins and subsurface injection have been used. The success of the method depends on the choice of location and various other factors, such as precipitation, drainage, slope, soil type and permeability, land use and cover, geology and geomorphology.

(g) Induced Artificial Rainfall. The term artificial rain is the term used to describe a method of creating non-natural rainfall. The development of artificial rain methods took place at the end of the 2nd World War. For such purposes, large clouds are usually selected, sprayed either by an airplane or with special ground machinery (e.g. guns or special ground missiles), equipped with suitable condensation cores. Israel began using technical rain technology in the north since 1950. This included the emission of silver iodide from airplanes and ground assets. As of 2021, Israel stopped using this technology because of its variable results, high cost, and the availability of improved desalination technologies.

(h) Petrified water. Fossil water or palionero is fresh water of the past, formed centuries ago in huge aquifers, which were created under old geological formations. It is an ancient water that can be found in undisturbed underground geological formations. It is a valuable but finite and non-renewable water resource. It can be an important source of groundwater in areas/periods of water scarcity. When fossil water is extracted, its exploitation is as a non-renewable water source and is commonly referred to as groundwater extraction. The water is of a quality suitable mainly for irrigation, providing crops with nutrients as well.

(i) **Dew water.** A gaseous mass can contain a certain amount of water vapour, depending on the temperature and pressure of the air, and is called a dew point. Dew water is created almost all over the planet from atmospheric moisture and can be converted into drinking water when it falls on a cold surface. The amount of water vapor that a gaseous mass can hold, decreases with decreasing temperature; Dew is formed mainly on the leaves of plants and grass. In wet areas its importance is not essential, while in arid areas it can be a source of water supply even for irrigation of agricultural crops. In Greece, the dew phenomenon is observed in island, coastal and lowland areas in autumn and especially in November, while in mainland and mountainous areas, it is observed in spring and mainly in May.

(j) **Fog water.** Fog water is suspended droplets of water and moisture in the atmosphere or near the earth's surface, in some areas. Fog water is an important component of the water cycle, of high quality, important in areas/periods of water scarcity. Collecting water from fog, as a source of drinking water, using innovative technologies, could be a sustainable drinking water supply practice; without any energy consumption and at low cost. Generally it is fresh water of good quality vital, which should be taken into account.

(k) Iceberg Water. A descrete iceberg is another unconventional water resource that can be transported and used to produce water in places that need water, such as arid and semi-arid areas. Iceberg water is considered to be a clean, unconventional water resource, and is potentially an excellent new source of water. In a world where the purity of even bottled water is questionable, melted iceberg water somehow ensures high purity drinking water. However, it has a major problem related to the difficulty of transporting large icebergs over open sea routes as well as the loss of water during transport due to melting when coming in contact with warmer seawater.

Undoubtedly, the prevailing weather conditions dictate the consideration of unconventional water sources in the Integrated Water Resources Management plans in the water districts of our country. The current circumstances offer us the opportunity to take the lead at European Union level.

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*Andreas N. Angelakis is an Honorary Member and Distinguished Fellow of IWA (International Water Accosiation).

** George Tsompanoglou is Professor Emeritus at the University of California, Davis, CA., USA.

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