

Article

History of Hygiene Focusing on the Crucial Role of Water in the Hellenic *Asclepieia* (i.e., Ancient Hospitals)

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Abstract: Prehistoric Hellenic civilizations like many other civilizations believed in gods and thought they had influence on the everyday life of the people. During the Bronze Ages the explanations of illness and health problems were based on mythological, divine, or religious (i.e., theocratic) reasoning or explanations. However, during the Classical and the Hellenistic periods, the Greeks clearly differentiated their thinking from all other civilizations by inventing philosophy and empirical science. Drains/sewers, baths and toilets and other sanitary installations reflect the high cultural and technological level of the period; they are also associated with hygienic and medical studies and practical applications. At that time, medicine was mainly based on clinical observations and scientific investigations. Prior to that time, in the Bronze Age, medicine was entirely confined to religious rituals and beliefs. In ancient Greece, medicine was practiced in *Asclepieia* (or *Asklepieia*), which were healing sanctuaries which also functioned as medical schools and hospitals. In the Classical Greece period, more than 400 *Asclepieia* were operating offering their medical services. The basic elements of each *Asclepieia* included a clean source of water and related infrastructure. At that time Hippocrates, the father of medicine, and his successors wrote a large number of medical texts in which the crucial role of water and sanitation is documented. They also identified numerous medical terms, many of which remain in use today. The Hippocratic treatises also contributed to the scientific evolution which occurred in later centuries, because they sought to explain the causes of observed natural phenomena in a deterministic way rather than on theocratic explanations in use at the time. In this paper, the evolution of hygiene, focusing on water use in ancient Greece is examined.

Keywords: *Asclepieion* and *Asclepieia*; Minoan Era; Classical and Hellenistic periods; Hippocrates; God offerings; medicine; sanitation; water

1. Prolegomena

Water contributes much towards health

Hippocrates (ca. 460–370 BC), the famous ancient physician

The earliest known permanent settlements, which can be classified as urban, occurred in the early Bronze Age in Minoan Crete about the 3rd millennium BC. The settlement included purposeful construction and operation of the water supply networks, bathrooms, toilets, and drainage and sewerage systems. At the same time, similar sanitation infrastructures (e.g., water wells, water pipes and toilets) were known in Egypt, Mesopotamia, and in Indus valley (the city of Mohenjo-Daro, located in modern Pakistan). There is evidence from the very beginning of humankind that confirms the importance and safety provided by water and sanitation [1] (Rose and Angelakis 2014). The benefits of water supply and sanitation were known, more or less, since the early rural societies. When water supply and sanitation infrastructure was implemented, health problems and environmental risks began to decrease. The value of water and cleanliness was known from ancient myths and civilizations. The significance of water was also recognized in religious ceremonies by ancient Hellenic civilizations. In addition, Classical Greeks were the first known philosophical thinkers and medical writers which recognized the importance of water for the human health and hygiene [2] (Vuorinen et al. 2007).

The roots of modern medicine and the evolution of sanitation in the Hellenic world can be traced to Classical Greece. During this period there were two different approaches in Hellenic medicine: (a) the predominate religious medicine of the god Asclepius and (b) the philosophical medicine of Hippocrates, Herophilus, Erasistratus and Asclepiades. The scientific approach and study of medicine and its relationship with sanitation was established in parallel with the still predominant religious oriented approach practiced in *Asclepieia* (or *Asklepieia*), which initially were healing sanctuaries, but later also functioned as medical schools and hospitals [3] (Risse, 1999). In the Classical period, more than 400 *Asclepieia* were operating offering their medical services. The basic elements of each *Asclepieia* included a clean source of water and related infrastructure for utilizing the water. In the available written documentation, a clean source of water appears to be a key element of the *Asclepieia*. As reported by [4] Manutsoglou (2017), it was thought that waters from springs at *Asclepieia*'s had healing properties, offering relief to sufferers and patients. The development of *Asclepieia*'s is examined in detail in the following sections.

Outstanding among the medical practitioners, was Hippocrates (460–377 BC), universally regarded as the father of modern medicine who was free of mythological beliefs [5,6] (Yapijakis 2009; Shephard 2015). In his treatise *Airs, Waters, and Places*, the effects of the climate and the environment on human health are considered. In Hippocratic medicine, every disease has its natural logical causes, which are internal, deriving from a man's bad body constitution or unsuitable dietetics, or external, coming from the environment. Additionally, the characteristics of the various categories of waters (e.g., stagnant, salty, rain, and soil) which flow in different areas are described. The role of nature is crucial in the Hippocratic medicine, because the human body is part of the environment and the physician helps the patient to return to the initial, natural healthy condition [7] (Galanaki 2014). Several Hellenic medical authors (e.g., Diocles of Carystus, Galen and Paul of Aegina), extended and improved the Hippocratic work [8] (Vuorinen 2014). A few physicians, nevertheless, opposed Hippocratic beliefs, based on their benevolent nature. The most remarkable of these was Asclepiades of Bithynia, who was the first known physician who spoke about what is known today as molecular medicine and made the highly important division of diseases into acute and chronic ones [5] (Yapijakis 2009).

The principal objective of this paper is to trace the birth and application of hygienic themes in the Hellenic world, through existing written historical sources of various types and through the numerous relevant archeological remnants. Another objective of this paper is to identify what brought about the change from a theocratic (i.e., mythological, divine, or religious) approach to the scientific one. Thus, the material presented in this paper may be of interest to researchers and practitioners in biological, health sciences, environmental sciences, hydrology, archeology, history,

and engineering. In addition, historical understanding may provide interdisciplinary lessons from past triumphs and failures of mankind's empirical knowledge of multiple centuries.

2. Precursor Structures of *Asclepieia* in Prehistoric Times

In the Minoan Era (ca. 3200–1100 BC) there is no indication that Minoans were aware of the causes of human illness. During this period, explanations for human illness were based on theocratic beliefs. In the Hellenic mythology the meaning and spirit of the Minoan Goddess of the Snake had taken many different characteristics. For example, the snake had a protective role, by which the chthonic (underworld) power of the Goddess of Earth was represented [9] (Mays and Angelakis 2012). Trckova-Flamee [10] (2002) reported that it was probably due to the Asclepius' knowledge about the herb of rebirth, resurrection and eternal youth, and more generally it was the symbol of superhuman power. On the other hand, the snake could have a totally negative role too as a cause of the death and an avenger of the mythical creatures [10] (Trckova-Flamee 2002). Minoan Snake Goddess statue from Knossos palace was originally identified by Evans as one of her votaries is shown in Figure 1a. Gods were all female, not a single male god has been identified until now. Offerings (votives), an ancient custom, appears to be in practices in Minoan times. The offerings to the gods for healing were mainly relevant to the body parts (Figure 1b). In addition, there were sacrificial offerings such as killing, burning, smashing, etc., to appease to the gods.



Figure 1. (a) Minoan Snake Goddess; (b) offerings to the gods for healing were mainly relevant to the body parts (Photos A.N. Angelakis from the Museum of History of Medicine, University of Crete, Iraklion, Greece).

Minoan religion required believers to be always clean. Lustral basins and other purgatory facilities were found in several palaces, cities and other Minoan settlements used for ritual bathing. Such an infrastructure usually consists of a rectangular room reached by an L-shaped stairway [11] (Antoniou and Angelakis 2015). All lustral basins discovered so far are lined with gypsum [12] (Angelakis and Spyridakis 1996). Additionally, at Caravanserai (roadside inns), located opposite the main entrance of the palace of Knossos, where water from the aqueduct of Knossos was always available for visitors for cleaning. There was also the so-called sacred fountain.

In ancient Greece before Hippocratic times, knowledge of medical issues was limited. What is known about that time is derived from the numerous medical and anatomical descriptions contained in the epic poems of Homer, including the *Iliad* and the *Odyssey* [13] (Cartwright 2013).

3. The Religious Medicine of God Asclepius

In Homeric times (ca. 1100–800 BC), the most important god with therapeutic attributes was Apollo. Apollo represented the sun, which was associated with exceptional healing powers and therefore with the real origin of medicine. Much later, in ca. 7th–6th century BC, Homeric Hymns, who devote 546 lines to the god (to *Apollo*) certify his worship not only in the South, but also in Northern Greece (lines 33, 216).

However, quite early ancient Greeks transferred medical powers from Mount Olympus down to earth. Thus, Asclepius appeared. Galen, a physician of the Roman era (ca. 67 BC–330 AD) who believed in myths, remarks that before Asclepius medicine was based on experience and people were healed using only plants, while he made it an empirical science, by introducing new and different methods of healing. Accordingly, in the Hellenic mythology Asclepius (in ancient Hellenic: *Ασκληπιός*) (ca. 8th century BC) the son of Apollo and Coronis received the name from “to cut open” (from his mother when she died, cutting him from Coronis’s womb) [14](National Institutes of Health, 2013). Apollo carried Asclepius to the Chiron (in ancient Hellenic: *Χείρων*), who was considered the superlative centaur and the wisest and most just of all the centaurs, in order to educate him in medical practices.

Asclepius was a popular and influential healing figure throughout the Mediterranean [15] (Morehouse 2012). He also became so popular across the ancient Hellenic world and its colonies for his extraordinary healing skills that he was worshipped everywhere. This healer and comforting God was much loved in the entire Greek world. In the south, his cult was officially recognized at least until the end of ca. 6th century BC, even though his activities and contribution to the art of medicine were widely known since Homer, that is ca. 8th century BC [16–18](Edelstein and Edelstein 1945; Kerenyi 1948; Kallegia 2000). In the north, first established archaeological evidences for the worship of Asclepius go back at least the first half of the ca. 4th century BC, which are mainly coming from the colonies for example from Amphipolis, Olynthus, and Potidaea [19,20](Voutiras 1993; Comella 2002). It is well known that Macedonian kings, such as Perdiccas II, Amyntas III, Philip and Alexander the Great had a great interest in medical art [21] (Greenwalt 1986).

According to myth, the tutor of Asclepius was Chiron, the wise old Centaur (*Κένταυρος*), who handed down from father to son secrets of the herbs of Thessalian mountain Pelion and who healed people without payment [22] (Gorrini 2003). Asclepius was worshipped as a god of health due to his skills as an ultra-doctor of medicine and was considered to have powers even to the resurrection of the dead, prompting the jealousy of the Olympian gods and the rage of Zeus, who struck him with a sharp metal bar [23](Mingren 2018). The two sons of Asclepius, *Machaon* (*Μαχάων*) and *Podalirios* (*Ποδαλείριος*) were worshipped as the gods of surgery and of medicine, respectively. Additionally, the three daughters of Asclepius, *Iaso* (*Ιασώ*), *Panacea*, (*Πανάκεια*), and *Hygeia* (*Υγεία*) were associated respectively with healing, therapy, and health. It is noted that the word hygiene comes from Hygeia, the Hellenic goddess of health. In the complex of the Great baths of Dion, six sculptures representing Asclepius and his family, dating back to the early ca. 3rd century AD have been found including a marble small child in a sitting posture, the therapist-demon *Telesphoros* (*Τελεσφόρος*) who was an attendant of Asclepius symbolizing the wish to overcome health problems [24](Pandermalis 1989). The connection between Asclepius and Telesphoros has been also observed both in the temple of Asclepius in the same city, and in the sanctuary of the Egyptian Gods in Philippi, as well as in an inscription from Thasos [18,24,25](Dunand 1997; Pandermalis 1989; Kallegia 2000). There is no doubt that neither the presence of this group of statues nor their location in a complex such the Great baths were selected at random. Their presence indicates the importance of the baths for therapeutic purposes.

According to an etymological approach the compound name *Ασκληπιός* (Asclepius) consists of the Hellenic words *ασκείν* (practicing) and *ήπιος* (mild), meaning the one that gently removes pain and illness. Another etymological analysis the Hellenic word Asclepius derives from the Hellenic verb *σκελλώ* (do something hard) which along with the privative phoneme A and the word *ήπιος* (mild) implies the one who prevents drying and necrosis of the body gently, with medicine [16,26](Edelstein and Edelstein 1945; Holtzman 1986).

4. Asclepieia

There were sanctuaries located in remote but beautiful areas, well known as *Asclepieia* or *Asclepieions* (in ancient Hellenic: *Ασκληπιεία*), dedicated to the healer-god, which functioned as medical centers for prognosis, advices, and healings [3] (Risse 1999). Trikki (today Trikala) regarded

as the place of Asclepius' birth and Epidaurus are considered the first places to worship Asclepius as a god, sometime early in the 5th century BC [27] (Melfi, 2007).

More than 400 *Asclepieia* were operating in the ancient world, offering their valuable services to the citizens. Most of them existed across the ancient Hellenic world. They swept over Greece during ca. 5th century BC. Since then the cult of the healer god became increasingly popular. That means that at that time almost every Hellenic city had an *Asclepieion*. In *Asclepieia* the god was worshiped in combination with Artemis who had healing power and was cooperating with Asclepius to cure diseases [28] (Kavvadias 1900). In all *Asclepieia* the role of water and cleanliness was crucial and there was no *Asclepieion* without a source of water. Literature sources and excavations indicate that *Asclepieia* were built in locations of great natural beauty, rich in vegetation, and with thermal springs [29] (Christopoulou-Aletra, 2010).

Geomorphology and natural environment played an important role in choice of the location of Asclepius' sanctuaries, as they were facilitating the development of worship. In each case, rich aquifers and natural springs were a major factor for the operation of these sanctuaries. In addition, the presence of rivers or constantly flowing torrents was composing an ideal environment for sacred centers dedicated to Asclepius. The close relationship especially between thermal springs, Asclepius and medicine is well known [17,18,30] (Kerenyi 1948; Krug 1993; Kallegia 2000).

They were not only areas of worship but also medical care centers. Thousands of people used to visit them so as to be healed from various problems, physical or mental health illnesses. They were combining experimental therapeutic methods with various religion and magical elements and the healing power of water. These included sacrifices, prayers, proper nutrition, taking of medicinal plants, hearing theatrical and musical performances and finally hypnotherapy. Special procedures, such as catharsis, exercises, massage and fasting were taking place there to obtain physical and mental recreation and healing. For those buildings such as theatres, gymnasia, hippodromes, sanitation installations were constructed next to the central temple or to the main buildings of every sanctuary, where physicians were practicing medicine. Finally, the crucial role of water in the procedures or sacred rituals and ceremonies in every *Asclepieion* is associated with the existence of aqueduct or any other local source of water (e.g., spring or well). Additionally, baths and toilets were fundamental water infrastructure in any *Asclepieion*. Fountains were perhaps the most basic element of Asclepius' sanctuaries, as the supply of running water was essential not only for ritual ceremonies, but also for all healing practices which were carried out there. Usually, the required water for purifications and other religious and therapeutic procedures was drawn from a water source that was embedded in the sanctuary. Such a water source, often springs or wells, generally deemed to contain curative properties [31] (Clark 2017). It is worth mentioning that a water source constituted an indispensable feature in sanctuaries of Asclepius [16,18] (Edelstein and Edelstein 1945; Kallegia 2000).

The *Asclepieion* was a center where people came for healing. The center included dormitories, dining rooms, baths and water supply facilities, and other structures. The symbol an *Asclepieion* was an entwined snake, which remains as a symbol of the modern medicine. What has been found at the *Asclepieion* was clay votive offerings largely of various body parts. The debate is whether they served as offerings meant as entreaties for healing that had not yet happened, or as thanks offering for healings of a particular part of the body as Minoans did. In Acropolis Museum in Athens a marble plate is presented showing Asclepius inside a temple (called *Naos* in Greek) with his wife *Hepione* and their daughter *Hygeia* receiving the dedications of worshippers. A young slave at the beginning of the procession leads a pig to sacrifice.

The worship of Asclepius was often inserted to already existing sanctuaries of deities who were related to his origin and life, like his father Apollo, or were having similar curative powers [16,19] (Edelstein and Edelstein 1945; Voutiras 1993). The coexistence of Asclepius, Apollo, and *Hygeia* and occasionally goddesses Artemis and Demeter was also equally common [16,28] (Kavvadias 1900; Edelstein and Edelstein 1945).

The patients made sacrifices or offerings to the god. Many others offered anatomical motives, which represent the body part that was injured or affected by illness. Most of them are made from

wood, bronze, stone, terracotta, and ivory (sculpture and painting). Additionally, it has been found that some offerings were made in materials that did not survive, as for example is in wax, gold, and silver [32] (Oberhelman, 2013). Anatomical votives were a special type of offerings, very common in healing sanctuaries [33] (Forsen 1996).

The sanctuaries were scattered throughout the ancient world, the most famous being those of Kos, where Hippocrates is said to have received his medical training, as well as those in Epidauros, Athens, Dion in Macedonia, Lissos, Gortys, and Levina (in Crete), Trikke in Thessaly, Corinth, Tegea, Messini, Olympia, Sparta, Kyrenia in Cyprus, in the Aegean islands Delos, Paros, and Rhodes, Bouthrotum (Northern Epirus, now part of Albania), Prience, Marseilles in France, Syracuse and Rome in Italy, and Erythrae, Izmir and Pergamon in Asia Minor. There was no Greek city at that time that did not have its *Asclepieion*. The westernmost sanctuary of Asclepius had been established on the island of the Tiber river in Rome (Isola Tiberina) [18,19,34] (Versakis 1913; Melfi 2007a & b; Kallegia 2000). A brief description of few *Asclepieia* follows.

4.1. *Asclepieion of Epidauros*

Epidauros was recognized as the most famous sanctuary of Asclepius's cult in Classical times, and it considered as the birthplace of *Asclepieia*, as Pausanias says. In Epidauros the theatre was built (ca. 6th century BC) from the donations of people who came there primarily to be cured at the *Asclepieion* and to provide entertainment. In Epidauros, in an area with mild climate and abundant thermal springs, was the *Asclepieion*, the basis of the medical god of antiquity and the most important therapeutic center of the whole Greek and Roman world. The *Asclepieion* in Epidauros (Figure 2) was organized around the holy water (later embedded in the gallery of *Avaton*). The water was a key element of healing, which was achieved by the process of purification and periodic sleeping "enkoimisis" near water, as an imitation of the way in which the divine forces ensured their renewal, returning with periodic death to the earth at the source of life, from which they were born again [35] (Psychogiou 2012). The god advised the patient during its periodic sleep, which is corresponding to the periodical death, about the treatment he had to follow.



Figure 2. Epidauros *Asclepieion*: (a) the abaton and (b) the well in front the Great Propylaea (photo A.N. Angelakis).

4.2. *Asclepieion of Kos*

One of the most famous *Asclepieia* is on the island of Kos, where Hippocrates is said to have received his medical training (Figure 3). Besides all the above, it should be mentioned that ancient doctors were honored for their services by their societies. Several honorific inscriptions have been found in sanctuaries and other public spaces, referring to the honors paid to doctors of that era, as for example that from Kos about Antipatros [36] (Kokkorou-Alevra 2004). In fact, it is said that Hippocrates had springs with healing water in the *Asclepieion* (therapeutic center) of Kos. These springs were also found in other centers, so that patients could take their bath in special tubs with mineral water. A fountain has been also found in *Asclepieion* of Kos [30] (Krug 1993), with water of healing properties (Figure 3b).

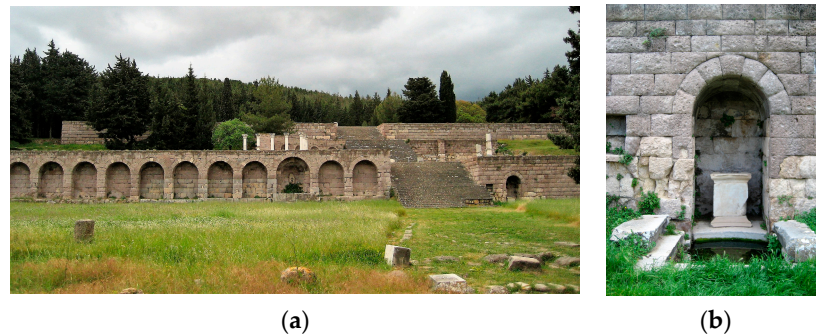


Figure 3. *Asclepieion* in Kos: (a) General view and (b) Roman fountain which replaced the large Hellenistic one (Photos G. Antoniou).

4.3. *Asclepieion of Emporiae, Spain*

In the *Asclepieion* in the Hellenistic city of Emporiae in the northwestern costal area of Catalonia, Spain, the major water source was rainwater which was harvested and stored in cisterns. The stored water in the cisterns was treated by ceramic filters before its use in the *Asclepieion* (Figure 4), an excellent example of the necessity of using purified water in *Asclepieia*. It is probably the first use of ceramic filters for water treatment in the world.

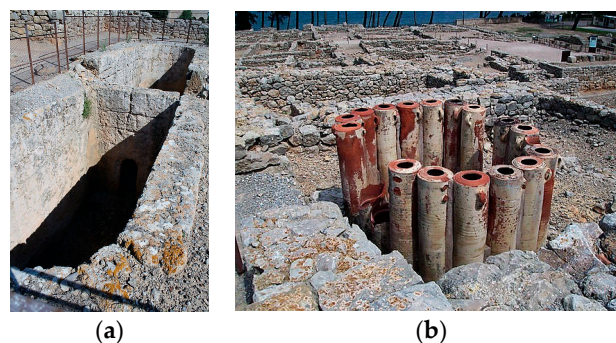


Figure 4. *Asclepieion* in the Hellenistic city of Emporiae in the northwestern costal area of Catalonia, Spain: (a) Water cistern and (b) ceramic water filters (<https://www.themata-archaiologias.gr/?p=11599><https://www.themata-archaiologias.gr/?p=11599>).

4.4. *Asclepieion of Corinth*

In the temple of *Asclepieion* of Corinth (Figure 5a) the necessary water for cult and hygiene was drawn from Lerna spring [37] (Roebuck, 1951), located in the southern site of Lerna court beneath the abaton (Figure 5b).



Figure 5. *Asclepieion* of Corinth: (a) General view with remnants of the avaton at the end of the picture and (b) the Lerna spring (Photos A.N. Angelakis).

4.5. Asclepieion of Athens

The Asclepieion in Athens (Figure 6a) located right above the theater of Dionysus was founded in 420–419 BC. The Asclepieion consisted of a small temple, an altar, two halls, a sacred spring for purification, the Doric Stoa (*abaton*) which served as a dormitory hall for the overnight stayed visitors to the Asclepieion, and were miraculously cured by the god who appeared in their dreams, and the Ionic Stoa (*katagogion*), which served as a guest-house used by the visitors to the shrine and the priests [38](Battuta, 2014). The Stoa integrated in to its eastern part of the sacred Spring, a small cave with a spring in the Acropolis rock, since water has always been a significant element in the cult of Asclepius, and in its western part the sacred *Bothros*, which functioned as a sacrificial pit. The sacred *Bothros* (pit), a well with polygonal masonry, placed in the first floor of the Stoa, probably served as a well. Altar is dated earlier than the Stoa itself, to the last quarter of the ca. 5th century BC. A fountain, was built with above the spring. It was incorporated in the abaton of Asclepius temple and had a circular form, just like the natural carving on the rock of the Acropolis' hill from where the water was outflowing [34](Versakis 1913).

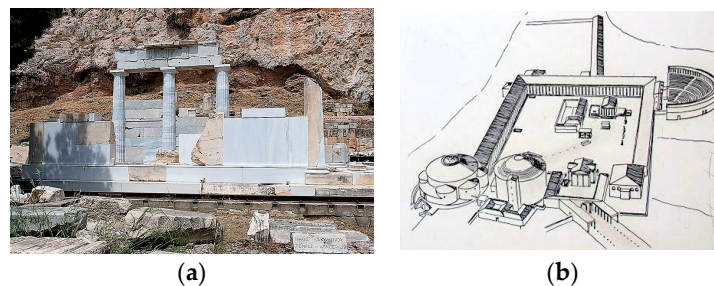


Figure 6. Asclepieia: (a) In Athens (its temple) (photo A.N. Angelakis) and (b) of Pergamon.

4.6. Asclepieion of Pergamon

The Asclepion in Pergamon (Asia Minor, modern Turkey) was an important health treatment and curing center equivalent of Epidaurus and Kos medical centers in ancient Greece and Rome (Figure 6b). The main treatment methods used in Asclepion of Pergamon included drinking Holy water, mud bath, thirsty and hunger cures, medicinal herbs, hearing the sound of water, keep fit exercises every day, putting on a weight and lubricated with cream [39](Ökçesiz, 2014). In addition, thousands of people used to come to Pergamon not only to be cured of their sicknesses, but also to enjoy the famous spa.

4.7. Asclepieia in Crete

Nearly a century ago, the thermal springs of Greece were recorded [40] (Lekkas, 1938). Most of them are associated with Asclepieias. Additionally, of the 750 recorded sources, almost 100 were recorded in Crete [40] (Lekkas, 1938). Special reference to this first record was made at the water source of the Asclepieia in Levina and in Lissos in Crete (Figure 7). There are indications that the water spring in Asclepieion of Levina was saline (salty) of having healing properties at a temperature of 22 °C, which was continued to be used for healing purposes in both the Historical and the Byzantine times [4](Manutsoglou, 2017). The Asclepieion of Lissos was possibly believed to be the main reason for the wealth of the whole city. Additionally, Manutsoglou [4] (2017) analyzed water samples taken from the spring in ancient Lissos in Crete, one during the hot season that the source was found to be hypothermic range from 20.3 to 20.7 °C, among the hot and cold seasons, respectively. The spring water in ancient Lissos, as shown by chemical analyses, was dominated by a calcium-magnesium-oxy|carbonate (Ca-Mg-HCO₃) mineral complex in both periods of time.



Figure 7. *Asclepieia* in Crete: (a) at Levina and (b) at Lissos (photo A.N. Angelakis).

5. From the Philosophical Medicine to Modern Medicine

5.1. Pre-Hippocrates Times

During the Classical period, the Pythagorean philosopher and physician Alcmaeon (in ancient Hellenic: *Αλκμαίων*) of Croton (in ancient Hellenic: *Κρότων*, Hellenic colony of Italy-Magna Graecia) who lived around 470 BC, stated originally about the possibility of the influence of the water quality to the health of people (*Aëtius*, at Opinion of the philosophers V. 30.1). Perhaps, he was a pioneer who had wondered regarding the possibility for inner causation of disease. He formulated the concept that maladies may be resulted by environmental malfunctions, nutrition matters and way of living. Additionally, Alcmaeon believed that good health was based on equality (*isonomia*, in ancient Hellenic: *ισονομία*) of contrary powers (wet and dry, cold and hot, bitter and sweet), while diseases were a disruption of this equality that he called “monarchy” [41](Diels 1879-*–). Alcmaeon is thought to be the first who suggested that the brain was the seat of mental capacity, the highest power of the soul. Alcmaeon, among others, was a great anatomist and the first who described the pair of nerves transmitting impulses to the brain from the retina at the back of the eye and the auditory tube inside the ear [42] (Malomo et al. 2006). He also invented surgical instruments and did brain surgery. Moreover, he issued a monograph named *On Nature* [43] (Durant 1939). Most possibly he was a philosopher about science rather than a physician as it is said by some historians [44] (Lambert 2012).

5.2. Hippocrates Times

Hippocrates (in ancient Hellenic: *Ιπποκράτης*) of Cos or Kos (in ancient Hellenic: *Κως*) (460–377 BC) is globally considered as the founder of contemporary scientific medicine, which is based on empirical observation of clinical signs and not on myths [5,6,45](Farrington 2000; Yapijakis 2009; Sheppard 2015, and others). Hippocrates said to have received his medical training at an *Asclepieion* on the island of Kos (Figure 3b). He developed a medical approach which was relied on examination and scrutiny of clinical matters and realistic interpretation and not to the religions or mystical approaches, or to divine displeasure, or other supernatural causes [5] (Yapijakis 2009). Details about Hippocrates we only know from his biography by Soranus of Ephesus, but he was regarded a great physician, the greatest, by ancient Greeks. For example, Aristotle refers to Hippocrates as the Great Hippocrates, the wise physician (Politics, VII. 4 (1326 a)).

Specifically, Hippocrates originally supported the logic of the diagnosis of illness. In his texts he often mentions the effect of drinking water on the human body. Hippocrates attributes the appearance of some diseases or even the weakness of some people to the bad water quality. Such are waters of high salinity that means salty, bitter, nitrite, sulfite, ferrous, acidic waters, or even rain waters which are perishable and can damage human cells or irritate the skin. These waters can also cause stomach aches, poisoning or vomiting (*Περί Αέρων, Υδάτων, Τόπων* and *Περί Χυμών*). Thus, other waters affect human health negatively, or cause even death, even though they are appropriate in other cases [7] (Galanaki, 2014). Hippocrates mentions that sea water is certainly not drinkable, however a sea bath could be beneficial in healing skin irritation or wounds (*Περί υγρών χρήσιος*).

Plutarch (*Αἰτίαι Φυσικαί*), Vitruvius (*De architectura*), Pliny (N. H.) and Aristotele (*Problems*) express similar views on the effect of water quality on human health. (Diodorus of Sicily also emphasizes the contribution of water in physical and mental health along with fresh air (...πρός ὑγείαν σωμάτων καὶ ῥώμην συμβάλλεται...)).

In addition to the above, Hippocrates considered that the prognosis and remedy should be relied on systematic scrutiny and on the consideration of human corpus. Additionally, Hippocrates was the first Western physician which has viewed the body as a whole in medical terms and has attempted to define a unifying system of medicine. Hippocrates introduced numerous medical terms (anatomic: *ανατομικό*, pathologic: *παθολογικό*, and therapeutic: *θεραπευτικό*) used universally by physicians with little or no change in meaning, as for example are symptom (in Hellenic: *σύμπτωμα*), diagnosis (in Hellenic: *διάγνωση*), therapy (in Hellenic: *θεραπεία*), trauma (in Hellenic: *τραύμα*), and sepsis (in Hellenic: *σήψη*) and many others. Moreover, Hippocrates depicted the appearance of numerous illnesses without superstitiousness. His terminology of the deceases is still applied nowadays in medicine, as for example are diabetes (in Hellenic: *διαβήτης*), gastritis (in Hellenic: *γαστρίτις*), enteritis (in Hellenic: *εντερίτις*), arthritis (in Hellenic: *αρθρίτις*), nephritis (in Hellenic: *νεφρίτις*), cholera (in Hellenic: *χολέρα*), herpes (in Hellenic: *έρπης*), pleurisy (in Hellenic: *πλευρίτις*), apoplexy (in Hellenic: *αποπληξία*), melancholy (in Hellenic: *μελαγχολία*), carcinoma (in Hellenic: *καρκίνωμα*), tetanus (in Hellenic: *τέτανος*), eclampsia (in Hellenic: *εκλαμψία*), coma (in Hellenic: *κώμα*), paralysis (in Hellenic: *παράλυση*), haematuria (in Hellenic: *αιματουρία*), mania (in Hellenic: *μανία*), panic (in Hellenic: *πανικός*), hysteria (in Hellenic: *υστερία*), epilepsy (in Hellenic: *επιληψία*), hepatitis (in Hellenic: *υπατίτης*), pneumonia (in Hellenic: *πνευμονία*), oedema (in Hellenic: *οίδημα*), and many others scientific words of Hellenic origin [5,46,47] (Jones 1868; Marketos and Ballas, 1982; Yapijakis 2009).

Hippocrates stated that disease had a physical and realistic exegesis and that thinking and feeling derive from cerebrum instead from the heart, in contradiction to convictions of numerous philosophers and scientists at that time. Influenced by the Pythagorean philosopher Empedocles (493–433 BC), Hippocrates based medicine on the philosophical idea that the natural world consisted of the elements of water, earth, air and fire [5] (Yapijakis 2009). Additionally, Hippocrates thought that corpus humanus consisted out of the following ‘humors’, as a term for liquids, the black and the yellow bile, the phlegm and finally the blood) and from the same number of qualitative conditions which were hot, cold, moist, and dry) [45,46] (Farrington 2000; Jones 1868). The combined balance of these two groups of ‘humors’ and qualities, were the determinant elements for the existence of health. Although this conclusion is quite unscientific according to the scientific approach used today, it was however “logical” in the extent that superstitiousness and religious beliefs had minimal contribution upon the arguments stated on that theory [48,49] (Retief and Cilliers 2000 according to Cilliers and Retief 2006).

As far it concerns illness, the healer had to reveal matters as the imbalance of the ‘humors’ and applying bleeding, emetics, purgatives, or even surgery to ease the therapeutic procedure [45,46] (Jones 1868; Farrington 2000). Hippocrates is the author of the saying: *Ο βίος βραχύς, ἡ δὲ τέχνη μακρὴ, ὁ δὲ καιρὸς οὐκ ἔστιν, ἡ δὲ πείρα σφαιερὴ, ἡ δὲ κρίσις χαλεπὴ. Δεῖ δὲ οὐ μόνον ἑαυτὸν παρέχειν τὰ δέοντα ποιεόντα, ἀλλὰ καὶ τὸν νοσέοντα, καὶ τοὺς παρεόντας, καὶ τὰ ἔξωθεν*, which can be roughly translated as follows: *Life is short; and the art long; and the opportunity fugitive; and the experience delusive; and the judgment difficult. It is necessary for the physician not only to provide the needed treatment but provide for the patient himself and for those beside him and to provide for his outside affairs* (from his Aphorisms). Hippocrates’ advice to the physicians was: *Ἀσκέειν, περὶ τὰ νοσήματα, δύο, ὠφελεῖν ἢ μὴ βλάπτειν* meaning roughly that: *strive, with regard to diseases, for two (things), (namely) to do good or to do no harm the physician must be beneficial to the patient or at least not harm him* or in other words *the medical act must be harmless to the patient, such that to alleviate the problems and not to increase or to create a new one*. This principle is now one of the main requirements of Medical Ethics and basic principle in the exercise of emergency medicine throughout the world.

A collection of ancient Hellenic works known as the Hippocratic Corpus cover a variety of medical issues, such as prognosis, therapeutics, dietetics and surgery are attributed to Hippocrates

or to his students. The Hippocratic Corpus is a collection of around 60 early ancient Hellenic medical works strongly associated with the physician Hippocrates and his teachings. A collection of approximately 60 medical scripts dated in the late classical to early Hellenistic period, is well known as the “Hippocratic Corpus” since it is strongly associated with the physician Hippocrates or his students and his teachings. In that Corpus incorporates not only textbooks but also philosophical essays on various medical subjects, as well as lectures, and research notes, arrayed randomly [50] (Rutkow 1993). Nevertheless, most of them are of unknown authorship and vary not only in content but also in style and age, (http://en.wikipedia.org/wiki/Hippocratic_Corpus). Despite the fact that the island of Kos located along the Asia Minor coast where Doric dialect of ancient Greek was used, every part of Hippocratic Corpus is written in Ionic dialect. According to Singer and Ashworth [51] (1962) the scripts of that Corpus were addressed not only to specialists but also to laymen. Often, they were written from opposing points of view and quite often between works in the Corpus significant contradictions can be found.

Hippocratic Oath is the most well-known script in the Hippocratic Corpus and is being considered as the landmark declaration of medical ethics. That Oath, despite its reference to relevant gods at the beginning, is actually a brief philosophical as well as practical script. Abstracted principles and practical matters—such as removing stones and aiding one’s teacher financially—are incorporated in the Oath. That multiplicate text was probably written by more than one author. Nowadays is in use, most of the times in an altered form [52] (Garrison 1921).

Hippocratic sleeve: Hippocrates also invented and used the first water filtering system, in the form of a cloth bag about 500 BC, known today as the Hippocrates’ Sleeve. It was used for removing the impurities from the drinking water after it was boiled. This early method consisted of a piece of cloth, folded at the corners, into which water could be poured, usually after being boiled, and then pass through to increase cleanliness for use in medical procedures and treatments [53] (Mays, 2013). Hippocrates is still revered for many of his contributions to health, and this dedication to clean water should be considered a major accomplishment.

5.3. Post Hippocratic Times

Alexandria, founded around a small, ancient Egyptian town ca. 332 BC by Alexander the Great, the king of Macedon, became an intellectual and cultural important center of Hellenistic civilization. At that time a medical school was founded, in which medical research became world renowned [54] (Serageldin, 2013). Two of the most eminent investigators of this school were Aristotelian physicians Herophilus (335–280 BC) (in ancient Hellenic: *Ἡρόφιλος*) and Erasistratus (in ancient Hellenic: *Ερασίστρατος*). Although it is known that both were authors of many scripts, none of their books have survived. In the writings of Galen, Celsus, and Tertullian, may be recovered limited parts of these works. Specifically, Herophilus of Chalcedon (in ancient Hellenic: *Χαλκηδών*, ancient Hellenic colony of Asiatic side of the Bosphorus) was a Hellenic physician and anatomist of the Hellenistic period and of the greatest doctors of ancient era [55,56] (Dobson, 1925; Wills, 1999). One generation after the Herophilus era, another important Alexandrian doctor, Erasistratus (325–250 BC) of Chios (in ancient Hellenic: *Χίος*), flourished. He was the first scientific physiologist [56] (Dobson, 1925). He described remarkably the human brain and cranial nerves, distinguishing not only the nerves in two kinds, sensory and motor, and noted their differences, but also the cerebrum from the cerebellum [57] (Dobson 1927).

In late Hellenistic period, one physician made a great difference. Asclepiades of Bithynia (124–40 BC) was the first Greek physician who established medicine as a respected profession in Rome by introducing a molecular and humane refinement of medicine in ways that have been appreciated only recently [58] (Yapıjakis, 2017). Asclepiades had studied medicine in Alexandria and Epicurean philosophy in Athens. Being an Epicurean, he did not believe in the Hippocratic theory of a “benevolent curing Nature”. Asclepiades for the first time introduced in medicine Epicurus’ atomic physics, which included chance and evolution [5,6,58] (Yapıjakis, 2009; Sheppard, 2015; Yapıjakis, 2017). During the Hellenistic times the important role of water and especially its quality in the health care field was widely recognized. From washing surgical tools and equipment

to creating a soothing environment for patients to have hydrotherapy, water was essential to the effectiveness of the health technology. However, the growth of microbes/pathogens and of course the waterborne diseases can be developed and spread through in the create favorable moist environments begun to be considered. At the same time the importance of cleanliness was also started to recognized.

6. Discussion and Conclusions

Hippocrates' influence to medicine is everlasting. A wonderful lesson for the present and future times could be recapped from the beginning of Hippocrates's Aphorisms stated that: Ὁ βίος βραχύς, ἡ δὲ τέχνη μακρὴ, ὁ δὲ καιρὸς ὀξύς, ἡ δὲ πείρα σφαλερὴ, ἡ δὲ κρίσις χαλεπὴ; meaning: "Life is short, and art is long, opportunity is fleeting, experience is perilous, and judgment is difficult". Furthermore, physicians should always remember his maxim: "Strive, with regard to diseases, for two (things), (namely) to do well or to do no harm; the physician must be beneficial to the patient or at least not harm him".

Understanding of the importance of clean water, hygiene, climate and the environment and the development of water and wastewater infrastructure, were instrumental in progressing medicine away from theocratic remedies for illness to those based on observational phenomena. As discussed by Hippocrates in his treatise on of *Airs, Waters, Places*, all of these elements are hallmarks of the ancient Hellenic times and cornerstones of modern civilization.

6.1. Clean Water

Public health and well-being have always been a major factor in the selection of water supply source. Typically, the selection of a water source was based on its physical characteristics (i.e., clear, tasteless, and odorless water) Both surface water, water from springs or wells were used, although the latter two were preferred. Since antiquity, it was known that certain kinds of water caused health problems (e.g., stagnant and marshy odorous waters). In 2014, Galanaki [7] (2014) stated that "Specifically, what is shown here is that diseases are less frequent in cities with an eastern aspect, since the waters which flow there are considered to be healthier and more suitable for drinking. On the contrary, cities lying to the West have the worst kinds of waters and they are thought to be the unhealthiest areas. Cities exposed to warm or cold winds do not have waters with balanced qualities, that's why they destroy the balance of the body qualities as well, causing excessive phlegm or bile, and, consequently, provoking a large amount of diseases". Hippocrates is also skeptical about some kinds of waters, e.g., stagnant, thermal, salty, rain, snow, lake and river waters and he mentions boiling as a way of making them drinkable [7] (Galanaki, 2014).

6.2. Importance of Climate and the Environment

The Hippocratic treatise of *Airs, Waters, and Places* is the only work which elaborates for first time the effects of climate not only in human health but also on ethics. As noted previously, the role of water is crucial in the Hippocratic medicine. The ancient Hellenic medical texts, which have survived until modern times, also contain excellent observations on the role of the environment and especially the water with regards to people's health. In his writings, Hippocrates discusses different types of waters and their effects on the inhabitants of the cities, giving many details on the disease conditions that they provoke, whether these are private or epidemic ones, stressing also the fact that, not only the waters, but the climate in general, is responsible for the shaping of the temperaments, the way of life and the ethics of the people [1](Rose and Angelakis, 2014). It was not until the late 19th century when the role of personal and public hygiene on people's health was understood more clearly [59] (Juuti et al., 2007).

6.3. Water and Wastewater Infrastructure and Health

The descriptions of urban sanitation technologies presented and discussed above, serve to illustrate the fact that such advanced technologies were in use in ancient Greece since about four thousand years ago. These technologies, developed originally in Minoan Era, were transferred subsequently to the Mycenaean civilization and then the Archaic, Classical, and Hellenistic Greece. The development of hundreds of *Asclepieia*, established all over the Hellenic world, was based on the understanding of the important relationship between water and health. The *Asclepieia*'s were located where a suitable environment and especially where clean water was available. Numerous *Asclepieia*'s were also in common use in the Roman Empire, but especially in Rome [60] (Renberg 2006–07). Based on historical and archaeological evidence, it is clear that the present-day progress in urban water technology as well as in comfortable and hygienic living is not a recent development. By providing an urban hygienic environment, the early Greeks are considered pioneers in developing the basic sanitation technologies in the western world. Recently, on 14 March 2017, the “International Network of Ancient *Asclepieia*” was established by the Hellenic Ministry of Foreign Affairs in cooperation with the Municipalities of Epidaurus, Kos and Trikala, to promote, record and highlight all the ancient *Asclepieia* that were operating in the Hellenic world [61] (Furla, 2017). Thus, through this network the important role of water will be clarified further.

6.4. Impact of Clean Water on Life Expectancy

Few references in the International literature deal specifically with the role of clean water and life expectancy, showed an increase in human longevity since the historical times which is due to a great extent, ca. 80% to water quality and sanitation improvements and ca. 20% to other factors, including medicine [62,63] (Reiter 2012; Thomas 1984). However, based mainly on the historical data in Greece it is noteworthy that life expectancy in Greece, during the Minoan Era (ca. 5000–3000 years ago) was a little less than 30 years old, in Classics and Hellenistic (ca. 2600–2100 years ago) just over 30 years, in 1947 it was 45 years and today it is 82 years. This increase in life expectancy was of course largely due to the quality of the water supply, medicine (e.g., vaccines contribute to a great extent), and hygiene conditions improvements, principles well established in the *Asclepieia*'s of ancient Greece. It is an exciting theme that reminds us that water is synonymous to life and water quality is synonymous to health [64] (Joan Rose, 2016 Stockholm water prize). Drinking clean water is closely tied to human health, as clearly expressed by the renowned physician Lewis Thomas: “There is no question that our health has improved spectacularly in the past century. One thing seems certain: It did not happen because of improvements in medicine, or medical science, or even the presence of doctors, much of the credit should go to the plumbers and sanitary engineers of the western world” [63] (Thomas 1984). We should always remember that “Water is life; but water quality is health” [64] (Rose 2016).

6.5. Hygiene and Medical Developments

As already mentioned, one of the three daughters of Asclepius was *Hygeia* (from ancient Hellenic word *Υγεία*). In addition to the mythology at Athens, Hygeia was the subject of a local cult since at least the 7th century BC. “Athena Hygeia” was one of the cult titles given to Athena, as Plutarch recounts of the building of the Parthenon (447–432 BC) (Plutarch. Life of Pericles 13.8). Thereafter, the following Hellenistic period (ca. 4th–1st centuries BC) is considered as the most progressive time in hygiene, since the first sanitary and sewerage engineering infrastructures have designed and implemented. By the ca. 4th century BC anatomically shaped toilets seats were already used Greece, and by the ca. 2nd century BC lavatories were included in many private houses and public buildings [11] (Antoniou and Angelakis 2015).

However, “hygiene” was known as the branch of medicine dedicated to the art of health, as distinct from the therapeutic, namely the treatment of disease during the Hippocrates time. Hippocrates and his successors created a corpus of medical texts in Hellenic that was studied for

millennia; therefore, it is not surprising that many anatomic, pathological and therapeutic terms in those texts are still used today, often with the exact same meaning. In the antiquity, the first medical schools were founded in ancient Greece and in Magna Graecia (South Italy), namely in Sicily and Calabria. Among these schools, the most important was the Pythagorean. Undoubtedly, in a world still dominated by superstition, the foundation of the first great medical schools instilled a more objective ethical practice to their students. More or less the same principles were restated and embellished by contemporary medicine. Later, during the third century BC a famous medical school was established in old Alexandria, which was the major center of learning in medicine in the ancient world for about four centuries, until great Greek physicians (like Asclepiades and Galen) after their education in Alexandria moved to Rome and flourished there.

Several other Greek physicians advanced the medical art, and among them, Alcmaeon of Croton (ca. 535 BC) is thought to be the first who suggested that the brain was *the seat, in which the highest, principal power of the soul is located*; Aristotle (384–322 BC), the greatest classical biologist and probably the first anatomist, proposed the cardiocentric theory; Diocles of Carystus (flourished in the 4th century BC) affirmed the central role of the heart; Herophilus of Chalcedon (335–280 BC) carefully described at least seven cranial nerve pairs, including the optic, oculomotor, trigeminal, motor root of the trigeminal, facial, acoustic and hypoglossal nerves. Herophilus introduced a new nerve physiology by proposing the pneumatic mechanism; Erasistratus of Ceos (310–250 BC), who is regarded by some as the founder of physiology, described remarkably the human brain and cranial nerves, identifying nerves for sensation and nerves for movement. Nowadays, the clear description of many neuroanatomical structures and the development of neuroscience represent the legacy of Herophilus and Erasistratus. Last but not least, Asclepiades of Bithynia (124–40 BC) introduced a molecular approach and humane refinement of medicine in ways that have been appreciated only recently [59] (Yapıjakis, 2017).

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