Review

Water Quality Focusing on the Hellenic World: From Ancient to Modern Times and the Future

Andreas N. Angelakis [1,2,*], Nicholas Dercas [3] and Vasileios A. Tzanakakis [4,*]

1 HAO-Demeter, Agricultural Research Institution of Crete, 71300 Iraklion, Greece
2 Union of Hellenic Water Supply and Sewerage Operator, 41222 Larissa, Greece
3 Department of Natural Resources Management and Agricultural Engineering, Agricultural University of Athens, 11855 Athens, Greece; ndercas1@aua.gr
4 Department of Agriculture, School of Agricultural Science, Hellenic Mediterranean University, 71410 Iraklion, Greece
* Correspondence: angelak@edeya.gr (A.N.A.); vtzanakakis@hmu.gr (V.A.T.)

Abstract: Water quality is a fundamental issue for the survival of a city, especially on dry land. In ancient times, water availability determined the location and size of villages and cities. Water supply and treatment methods were developed and perfected along with the evolution of urbanization. In Europe, after the fall of the Roman Empire, water supply and sewage systems went through fundamental changes. However, in medieval times, the lack of proper sanitation and low water quality increased the spreading and effects of epidemics. The importance of potable water quality was established during modern times. In Greece, the significance of water filtration and disinfection was not understood until the beginning of the 20th century. Moreover, the beneficial effects of water quality and sanitation on human health and especially on life expectancy are considered. In Greece and other countries, a dramatic increase in life expectancy mainly after the 2nd World War is probably due to the improvement of potable water quality and hygiene conditions. However, since the mid-20th century, new water quality issues have emerged, such as eutrophication, the improvement of water treatment technologies, as well as chemical and microbiological water pollution problems. This study, in addition to the historical evolution of water quality, highlights and discusses the current issues and challenges with regard to the management and protection of water quality, including global changes in population and urbanization, lack of infrastructure, use of nonconventional water resources, spreading of emerging pollutants and contaminants (e.g., antibiotics and microplastics), and climatic variability impacts. Against these, a review of the main proposed strategies and measures is presented and discussed to protect water quality and maintain water supplies for the future. Understanding the practices and solutions of the past provides a lens with which to view the present and future.

Keywords: water quality; prehistoric times; historical periods (i.e., archaic; classical; Hellenistic and Roman); byzantine; middle age; ottoman; life expectancy; water filtration; nonconventional resources; emerging pollutants

1. Introduction

> *The history of water is equivalent to the history of the world and the history of water quality is equivalent to the history of life.*

(Andreas N. Angelakis)

Since prehistoric times, the need for producing pure water has resulted in the development of water purification methods (e.g., filtration, sedimentation, and decontamination). Ancient civilizations, such as Minoans, Indus Valley, Mesopotamians, Egyptians, and Chinese applied these methods [1].

In ancient Greece, due to the rapidly growing urban population, the settlements were forced to transport water through aqueducts to store it in cisterns and dams and to distribute it to the people through network systems. Greek civilizations were among the first expressing their interest in water quality [2]. Aeration tanks and other devices were used to treat water. All major ancient cities in the Hellenic world, which lasted for millennia, were established in dry areas with low water availability, in contrast to other ancient civilizations (e.g., Egyptians, Mesopotamians, and Indus), which developed in regions with high water availability [3]. These ancient Greek settlements were built on the top of hills and/or on dry areas for safety and hygienic reasons and so as to avoid occupying fertile lands [4,5]. Moreover, water treatment technologies (e.g., filtration, sedimentation, and decontamination) were developed and operated to improve water quality [6].

In early prehistoric times, when water from a spring or a well or during a siege was not accessible, it was supplied from cisterns, which were only used for drinking and cooking purposes at 3−5 L per person per day (L/p·day) [7]. On the other hand, the average water demand in Classical Miletus during its early times was 18 L/p·day [6].

During the Archaic and Classical periods (ca. 750–323 BC), aqueducts were further developed, and their scale was increased. However, water quality was not significantly improved. In the Hellenistic period (ca. 323 BC–31 BC) hand-dug wells and springs were used to meet water demands. In addition, the construction of cisterns became a widespread practice in many cities during those times [6]. Furthermore, following the classical tradition, aqueducts continued to be subterranean. The cleaning of water took place on sedimentation tanks and sand filters. During the Roman period, Romans, known for their knowledge, craftsmanship, and ability to implement engineering projects (e.g., aqueducts, drains, and cisterns), developed advanced technologies for sanitation, such as baths with flowing water and underground sewers and drains. Moreover, the scale of hydraulic works was highly increased in rich and well-developed urban regions [8].

Life expectancy in the Hellenic world was very short, which is mainly attributable to poor water quality; the connection between water quality and life expectancy and how these have entangled and influenced each other over time has been studied by a recent study, where several examples from all over the world were considered [9].

Water quality has been to a certain extent considered since prehistoric times. Rainwater was usually collected in cisterns from rooftops and open courts. Special care must have been given to secure clean surfaces in order to maintain the purity and quality of collected water by (a) cleaning the surfaces used for collecting the runoff water and (b) by the use of filtering devices (e.g., coarse sandy filters). The water collected in the cistern was primarily used in crafts (e.g., pottery and metallurgy), domestic activities, and in the irrigation of gardens [10]. It could be used for drinking only in the case of drought or siege.

The evolution of water quality and its use for purification has changed significantly over the centuries. This change is due both to technological developments and to the introduction of regulations but also to other factors such as religion and its imperatives, prejudices, epidemics (especially in times of limited scientific knowledge), and contacts between populations due to migration or to wars. Thus, the health of each people depends on the level of its development and on the aforementioned factors.

The Greek concept of hygiene, for example, "had emerged as a specialized medical discipline that attempted to control every aspect of the human environment—air, diet, sleep, work, exercise, the evacuations, passions of the mind—and to incorporate them into a 'sanitary' or wholesome way of life" [11]. Greeks linked cleanliness with healthfulness; they brought us their sociable public baths, which were also adopted by the Romans who made baths a main part of their social life [12].

For centuries, married Jewish women of menstruating age were among the cleanest people; ritual purity mandated thorough monthly baths [12]. Muslims introduced showers, as washing five time a day and bathing was part of the duties of worship in Islam. Cleanliness improved during the Middle Age, particularly after the Crusaders imported the Turkish bath and Saturday baths became commonplace. Public bathhouses were popular

and well-run, especially in Paris and London, and pregnant women used them for "baby showers," or festive "lying-in baths" with their female friends [11].

As from the 16th century, the cleanliness tendency was reversed; people stopped bathing, most probably due to the fear of diseases. Ashenburg [12] blames the plague, while Smith [11] indicates syphilis as a more likely factor, which was prevalent during the 16th century. At that time, doctors thought that bathing was dangerous because it opened the skin to malign "vapors". Moreover, the church accused baths for encouraging concupiscence. From the mid-16th century and until the 19th century in many European countries, a person could go from cradle to grave without a good wash. As Ashenburg says, "water was the enemy, to be avoided at all costs" [12].

The present study collects information on the evolution of water quality through the millennia, with emphasis on the Hellenic world, to record and highlight the importance of water quality protection to sustaining life on the planet. Additional information is provided to record current trends, as well as current and future challenges for humankind to protect water quality and preserve the sustainability of water resources.

Water quality from ancient to modern times is also the story of how the quality of the water evolved from ancient times to its decline with the development of intensified water treatment methods in the late 1800s and early 1900s, and later to its rebirth due to population growth, the development of megacities, climate variability, rapid developments in technology, and the fact that the amount of fresh water in the world is finite. The information presented is intended to promote a new vision of water quality and to highlight the important role it will play in meeting future water needs, especially as the population of the world continues to grow.

This review paper is organized as follows: Section 1, Introduction, is an introduction to the theme and elements of the review, followed by Sections 2–4 which explain the distinct history of water quality from the prehistoric era to the present time in a geographical and chronological view, including various hydro-technologies used. Section 5 focuses on emerging trends and the current and future issues and challenges of water quality. Finally, Section 6 is the epilogue that includes conclusive remarks and highlights.

2. Water Quality in Prehistoric to Medieval Times (ca. 3200 BC–1400 AD)

2.1. Prehistoric Times (ca. 3200–1100 BC)

Early prehistoric civilizations flourished on plains close to river areas, where water was readily available (e.g., Mesopotamians, Egyptians, Indians, and Chinese civilizations). The earliest known permanent settlement, which can be classified as urban, is Jericho from ca. 8000–7000 BC, located near springs and other bodies of water. In Egypt, there are traces of wells and in Mesopotamia of stone rainwater channels from ca. 3000 BC. From the early Bronze Age city of Mohenjo-Daro, located in modern Pakistan, archaeologists have found hundreds of ancient wells, water pipes, and toilets [13].

On the contrary, the majority of the earliest Greek societies usually avoided the establishment of their major urban centers close to areas with high water availability (e.g., rivers, lakes, or rich springs) [14]. Close observation of the locations of these centers suggests that the ancient Greeks chose to establish most of them in the driest areas. The exact reasons for this are not clear, but we can assume that ancient Greeks of the prehistoric periods considered a dry climate as more convenient or healthier; ostensibly, this choice of location offered good protection from floods and water-related diseases [15].

During the Bronze Age (ca. 3200–1100 BC), the lack of water limited the inhabitation of the areas within close proximity to water resources (e.g., wells and springs) of low water availability. The Indus Valley and Minoan civilizations considered water availability and security as one of the critical aspects of the design and construction of their water supply systems. Water security is also a contemporary concern around the world, particularly from the viewpoint of adequate water supply and mainly safety [16]. Moreover, the first evidence of the purposeful construction of water supply, bathrooms, toilets, and drainage in Europe comes from Bronze Age Minoan Crete in the second millennium BC.

The earliest recorded attempts to use clean water date back to 2000 BC. Since those times, the need for pure water has resulted in the development of primary water purification methods. These methods, probably, were incapable of removing disease-causing microbes but formed, however, the basis of the modern purification methods (e.g., filtration and decontamination). Initially, they used boiling or placing hot metal instruments in water before drinking it, as well as the filtering of water by using crude sand or charcoal filters [17]. Around 3000 BC, the city of Mohenjo-Daro (Pakistan) used a very extensive water supply system. In this city, also, there were public bathing facilities with water boiler installations.

The Minoans originally focused on water treatment to improve the aesthetic characteristics of drinking water [6]. The prehistorian Greeks and Indian civilizations, dating back to ca.2000 BC, were the first to consider the water supply and treatment [18]. Since the early Minoan time, they were based on rainwater harvesting, e.g., in Chamaize and Trypiti settlements in the eastern part of the island of Crete. These systems were further improved in the Neopalatial period (ca.1650–1450 BC), when, in several Cretan settlements (e.g., Knossos, Phaistos, Agia Triada, Chameisi, Pyrgos Myrtou, and Fournou Korifi), water supply was dependent on atmospheric precipitation. In these locations, rainwater was collected by runoff water from cleaning opened surfaces (e.g., yards and roofs) and filtered in coarse sandy filters before it flowed into the cisterns (Figure 1a) [7]. Moreover, to remove the suspended solids from the water as sediment, small cisterns of stone (sedimentation tanks) were used before the collected water, and it was stored in the main cistern (e.g., in Tylissos, shown in Figure 2b). A representative cylindrical-shaped cistern is shown in the background of Figure 1.
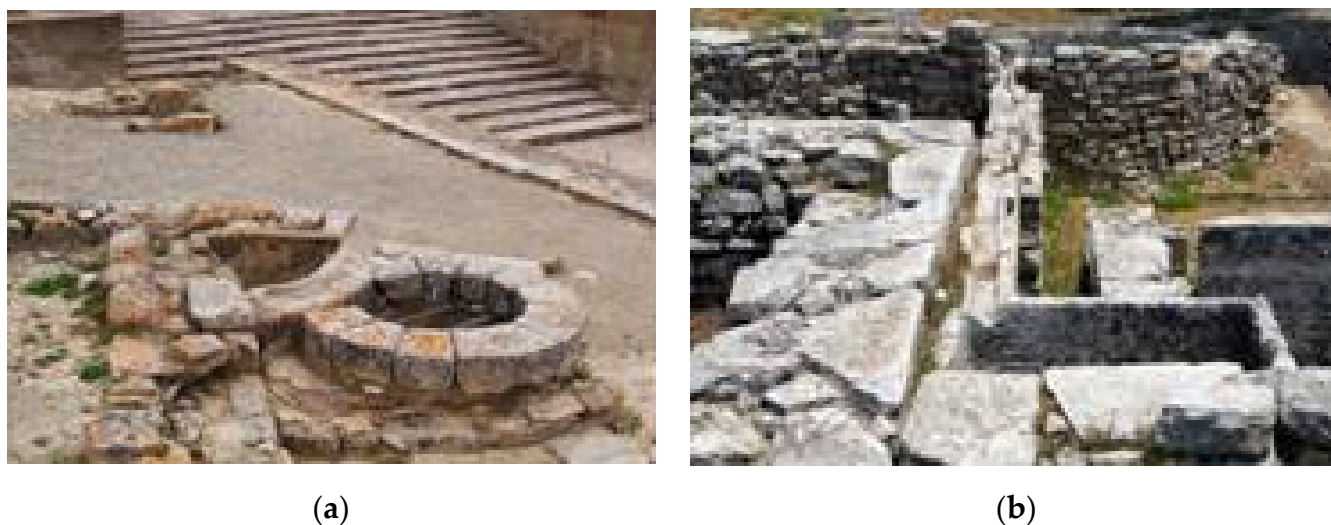

(a)   **(b)**

Figure 1. (**a**) Special cistern with coarse sandy filter and (**b**) small stone-made cistern used as sedimentation of suspended solids in Tylissos (Photos A.N. Angelakis).

One of the salient characteristics of the Minoan era in Crete was the treatment devices used for water supply in palaces, cities, and villages from the beginning of the Bronze Age. It is truly amazing that the most common water quality modification technique for providing suitable domestic water supplies was already known to Minoan engineers [14]. In the late Minoan period, for the achievement of clarity and/or turbidity, which are considered as the main criteria for classifying water as suitable for potable use, practices similar to today were used [7]. Thus, according to [19], a strange, oblong device with an opening in one of its ends was used to treat domestic water (Figure 2).
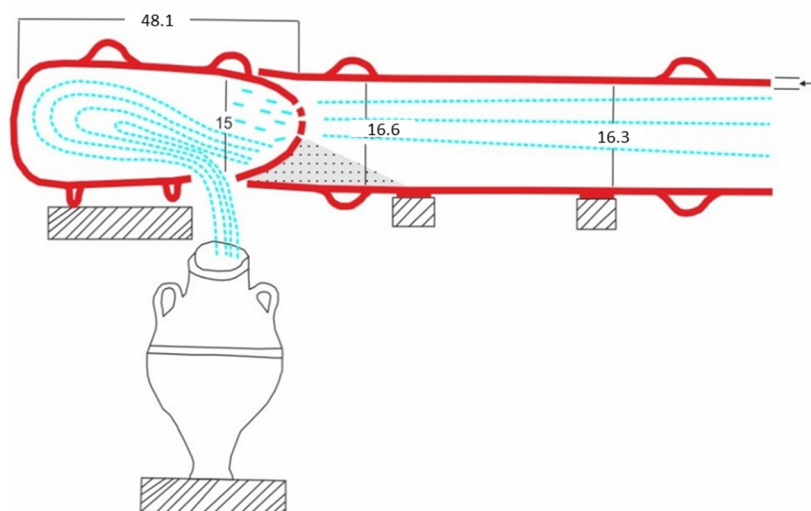
Figure 2. Minoan water ceramic filter (units are in cm) (Angelakis et al., 2020).

2.2. Iron Times (ca. 1100–750 BC)

During the Iron age (ca.1100–750 BC), rock cutting made it possible to establish small villages on high and protected hills. There, it was possible to build cisterns under their houses and collect and store water during rainy days in the winter and use it during dry times. Based on this, hundreds of people were supported by relocating to well-protected areas. Moreover, people living in big cities were allowed to cut rocks and to build underground aqueducts in order to reach remote water springs. However, minimal information is available on water quality at that time.

2.3. Historical Times (ca. 750 BC–476 AD)

2.3.1. Archaic Period (ca. 750–480 BC)

The first urbanization in Europe occurred during archaic times in the eastern Mediterranean region in areas with relatively modest rainfall. In this period, the archaeological evidence was enriched and improved our ability to study the relationship between water and people's health [20].

During that period, Pythagoras (ca. 570–495 BC), a philosopher, and Alcmaeon of Croton (in ancient Greek: *Αλκμαίων του Κρότονα*), the first physician and physiologist in the pre-Hippocratic medicine and probably a pupil of Pythagoras, were the first to consider the possibility that water quality may affect human health (*Aëtius,* at Opinion of the philosophers V. 30.1) [21]. Alcmaeon was a pioneer who wondered about the inner causation of disease. He formulated the concept that diseases may result from environmental malfunctions, nutrition matters, water quality, and way of living [21].

2.3.2. Classical and Hellenistic Periods (ca. 480–31 BC)

Archaeological excavations and historical information provide pieces of evidence of the cultural explosion that occurred in Greece since the very early times of the Classical period (ca. 480–323 BC), including various disciplines of water hydro-technologies, such as aqueducts, dams, water networks, and other sanitary and purification structures, especially those in urban areas [4]. In addition, special laws defined their use. Solon (ca. 630–560 BC), in his legislation, provided the relevant technical details, such as the dimensions of both the depth of excavation and the distance between the wells. Measures to prevent infections were also provided for. Later on, the laws of Plato (ca. 424–384 BC) mention the water supply management and beautification of the surrounding area of the fountain, which is fed by a spring, with plants, beautiful buildings, and sacred groves.

In 432 BC, Olynthus, founded in northern Greece, became the chief Greek city west of the Strymon River and a confederation of the Greek cities of the Chalcidice Peninsula [6].

There, similarly to Minoans, the water supply system was based on coarse sand filters in the ground to filter the rainwater before it flowed into the underground cistern (Figure 3). Cisterns, however, were not intended to receive a constant inflow because they were not primarily designed to facilitate a continuous outflow [22].
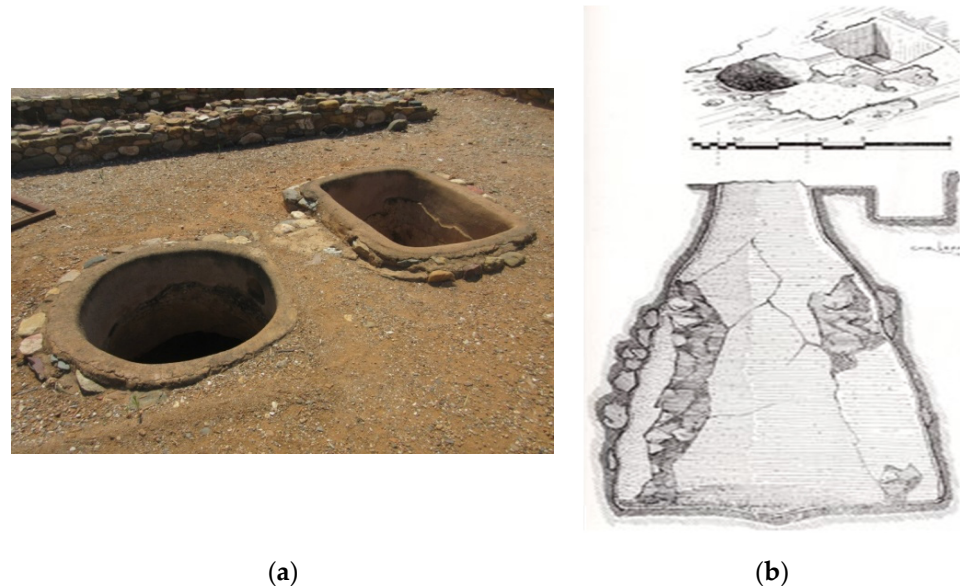

(a)   (b)

Figure 3. Olynthus bottle-shaped cistern with a small tank for pretreatment, including the capture of debris and sediment: (**a**) plan and (**b**) cross section [22].

Hippocrates (ca. 460–370 BC), who is considered one of the most famous scientists in the history of medicine, began to conduct his own experiments in water purification. He originally supported the logic of the diagnosis of illness. He conducted several experiments on water purification and recognized that the water of the aqueducts of the time did not reach the desired degree of purity. Therefore, he designed a fabric of cloth through which he poured boiled water [21]. In fact, he invented and used the first water filtering system, in the form of a cloth bag, in about 400 BC, known today as the Hippocrates' Sleeve (Figure 4). This material was used for removing the impurities from drinking water after it was boiled. Specifically, the method consisted of a piece of cloth, folded at the corners, into which water could be poured, usually after being boiled, and then passed through to increase cleanliness for use in medical procedures [23].

Figure 4. A Brief History of the Evolution of Water [1].

In all the ancient world, more than 400 *Asclepieia* (i.e., Ancient Hospitals) were operated. In all *Asclepieia* the role of water and cleanliness was crucial, and there was no *Asclepieion* without a source of water [21]. The aqueducts were perfected in the

Roman Empire (ca. 31 BC–476 AD) and were one of the most important state projects that enabled the cities to grow. This enabled cities with a population of hundreds of thousands to obtain fresh drinking and bathing water and to operate watermills.

In addition, in the *Asclepieion,* the Hellenistic city of Emporiae in the northwestern coastal area of Catalonia, Spain, where water availability was very low, rainwater was the primary source of water, which was harvested and stored in cisterns (Figure 5a). There, the stored water was treated through ceramic filters before its use in the *Asclepieion* of ca. 3rd century BC (Figure 5b) [21]. This is probably the first ceramic filter used worldwide for water treatment.
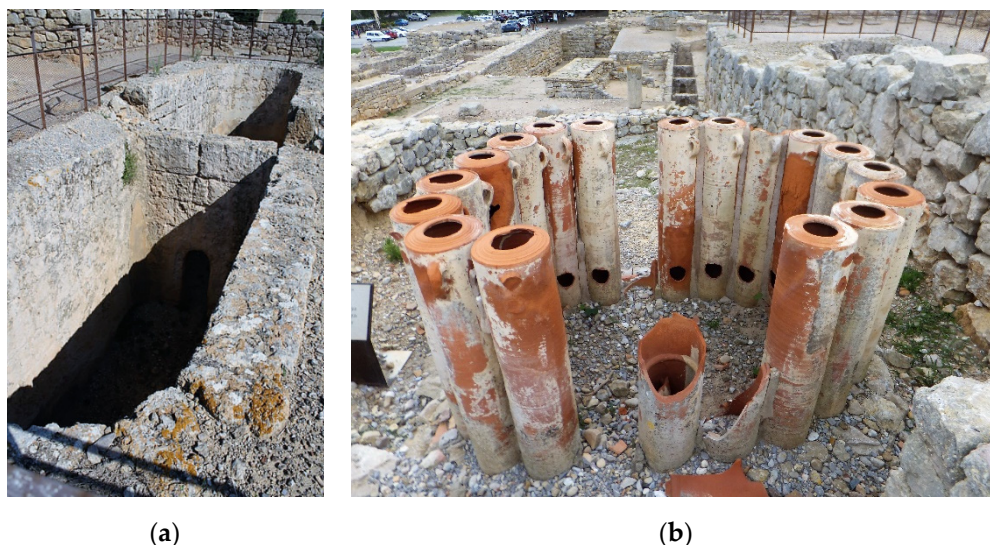

(**a**)　　　　　　　　　　　　　　　　　　　　　　　　　　　(**b**)

Figure 5. Cistern (**a**) and ceramic water filters (**b**) in the *Asclepieion* in the Hellenistic city of Emporiae, which is located in the northwestern coastal area of Catalonia, Spain [21].

On the other hand, Thucydides, who referred to the siege of Pylos in 425 BC, stated that the Spartans during the war surrendered due to the lack of food and water in "the desert island" (Thucydides, 4. 26). Moreover, Xenophon, in his *Hellenica*, referred to several instances where cutting off the opponents' water supply or polluting it was a well-proven strategy (Xenophon, *Hellenica*, 3.1.7) [23].

A good example of polluted water occurred during the Peloponnesian War in five years (430-426 BC). In the second year of the war, in 429 BC, the Spartans probably contaminated parts of the main water supply network and/or cisterns or wells in Piraeus; this was the source of water for a broader region in Attica, including Athens [21]. Available data show that the contamination of water caused the Athenian plague during the summer of the second year of the war, and it was probably due to salmonella (*Salmonella enterica* serovar *Typhi*), which was caused by using feces, rotten vegetables, or corpses [24]. Thucydides states that the plague from the polluted water first struck Piraeus and then Athens.

2.3.3. Roman Period

Roman times (ca. 31 BC–476 AD) improved the hydro-technologies of the Hellenistic period, mainly by increasing their scale. Aqueducts were usually the most common technology of water supply in Roman cities. Moreover, other technologies such as springs, percolation wells, dams, and weirs on streams were developed. These technologies are discussed extensively in the treatises of Marcus Vitruvius Pollio, a Roman architect and engineer who lived in the ca. 1st century BC [1]. A model of the two-story, four-chambered settling tanks (piscina limaria) in the aqueduct of Virgo Roman at the Pincian Hill in Rome is illustrated in Figure 6. During the 4th century AD, the population of Rome collapsed to just 30,000 people for reasons not fully understood and which are still now unknown. The

situation concerning water quality in other areas of Europe was generally unknown and remained so for a long time.

Figure 6. Roman times model (reconstruction) of the settling tanks (piscina limaria) on the aqueduct Virgo at the Pincian Hill in Rome, which is located in the Roman Civilization Museum in Rome [6].

Finally, Greeks and Romans used different methods to improve water quality by using settling tanks, sieves, filters, and boiling water. These were the methods used during antiquity. At least boiling water, which was widely recommended by the medical authors, would have diminished the biological risks of poor-quality water. However, the boiling of water might have been feasible only from a hygienic point of view. It was ecologically and economically not feasible for extensive use since firewood and other combustibles would sooner or later have become a scarce resource around the Mediterranean [13].

2.4. Medieval Times (ca. 476–1400 AD)

After the fall of the Roman empire, during the Middle Ages (ca. 476–1400 AD), i.e., Byzantine (ca. 324–1453 AD), Early Muslim (ca.650–1100 AD), Crusades, and the Mongols and Mamkuk period (ca. 1100–1516 AD), little progress was made in water treatment and sanitation and their connection to public health field. During this time, known as the Dark Ages, technological development, especially that related to water quality, was minimal due to the lack of scientific innovations and experiments [25]. Water supply was extracted from rivers or wells, which became highly polluted due to the discharges of wastes and others. To face that problem, people started to bring water from unpolluted rivers located outside the cities.

It should be noted that water sterilization methods, which were developed through ancient civilizations, show that any relevant scientific progress is based on the accumulation, practice, and use of the knowledge gained by scientists through successive civilizations. Greece maybe gained water sterilization methods which were developed during the Islamic time. At that time, Greeks, among others, probably passed through two consecutive stages in terms of obtaining sterilized pure water [26]: (a) The people focused on inventing several methods to help them get rid of the clearly visible bad qualities of water (e.g., color, turbidity, and smell). (b) The sterilization stage, where awareness led to the invention of new methods for using water without pathogens. These methods were the bases for several operations carried out today by scientists to reach the same goal, which is clean, sterilized water.

In addition, in Spain as well in Spanish America during the medieval and early modern times, a community-operated watercourse, known as an acequia, combined with a simple sand filtration system, was used for providing potable water [27]. In addition, in several other places in Europe at that time, few experiments were attempted in water purification or filtration. Devout Catholicism throughout Europe marked this time period. Due to the low level of scientific experimentation, the future for water purification and filtration seemed very dark. That did mark rejuvenation in water filter experimentation. Later, scientists followed

it and continued to deal with water filtration technology [17]. During the Middle Ages (ca.476–1400 AD), water supply was no longer as sophisticated. After the fall of the Roman Empire, enemy forces destroyed many aqueducts, and other water technologies were no longer applied. Thus, at that time, the future of water treatment was uncertain [5].

3. Water Quality in Early and Midmodern Times (ca.1400–1900 AD)

During the period of the Ottoman Empire (ca.1453–1900 AD), people covered their water needs mainly using fountains. The Ottomans reconstructed or repaired and used only a few aqueducts constructed by the Romans. These systems were made of stone elements and most of them continued to supply water until 1948. The town of Acre is a typical example of these aqueducts.

During the Middle Ages, there were no proper sanitation systems. This situation led to a high number of epidemics with devastating effects, especially in urban areas. The sewage system, which had been established and improved by Greeks and Romans, was left to deteriorate gradually. It was only in the mid-19th century that sewage drainage systems were constructed or repaired in a way that met the needs of public health, based on the progress of scientific knowledge and civil engineering.

The public latrines operating in medieval towns were few and could not meet the population's needs. They were often built near bodies of water and they projected water over a river. London, with a population of 25–30,000, only had sixteen public latrines. In Helsingör, Denmark, the executioners had the duty of emptying the cesspits, but they apparently were not efficient at their job. A Dutchman who lived there decided to empty his own toilet—thus annoying the locals—because the city officials were unable to do it. People made private toilets by digging in their backyards, even under houses and apartments. They dumped their contents in local lakes or rivers or used them as manure in agricultural areas [28]. This situation was deplorable as far as sanitation conditions were concerned. However, it was then that the distillation of potable water was first applied; it is most likely that distillation was used exclusively for specific purposes and not for broader community water services.

In the Venetian period (ca. 1204–1668 AD), especially in Crete, many water cisterns and fountain houses were constructed in towns and the countryside. In several Venetian cities and villages (e.g., in the Pediada region), which were densely populated and rich in water, significant water supply systems, expressed mainly in water cisterns, water filters, and fountain houses, were constructed [29]. In general, Venetians' accomplishments in hydraulics are worth noting, such as the construction and operation of aqueducts, cisterns, wells, baths, toilets, harbors, and fountains. Many of these technologies were developed and used in the famous castles constructed during that period [14]. Thus, several cisterns have been found in, e.g., Venetian Rethymnon, the island of Gramboussa, and in Viannos (in south-central Crete) Vigla castle. Moreover, small cisterns have been located in several villages in the area of Vamos, in western Crete. Later, pieces of evidence from the Venetian period suggest the existence of more than 500 cisterns in the city of Iraklion after ca. 1500 AD [30]. All those cisterns were collecting surface water from rainfall. During that period, rainwater harvesting technology was highly improved. This traditional hydro-technology is still in use in several Aegean islands, in eastern Crete, and elsewhere [14].

Several cisterns and fountains were implemented throughout the island of Crete during the Venetian period, such as a rectangular cross section in the Palaiokastron in eastern Iraklion used mainly for water supply (Figure 7a). The largest cistern in Iraklion (Chandax) during the Venetian time was built adjoining the Arsenal Nuovi (closed to the Venetian port) with a capacity of 2000 turns (450 m^3) served the port of the city (Figure 7b). The cistern consists of two oblong vaulted chambers linked by arched openings. Light and air enter the cistern through large light shafts at the vaults' top. Moreover, all the daily garden requirements of the port (about 7 m^3 of water per day) are covered by another underground cistern built by Venetians.

(a) (b)

Figure 7. Venetian hydro-structures: (**a**) cistern (of rectangular cross section) in the Palaiokastron in eastern Iraklion used mainly for water supply and (**b**) central cistern of two linked chambers in the Arsenal Nuovi (close to the Venetian port) in Iraklion city (photos by A. N. Angelakis).

Venetians and other Western rulers of many arid areas in Greece provided settlements and fortresses with small-scale rainwater harvesting formations. The cut in the rock cisterns of Palaiokastro in Pylos or relevant structures in Chora Amorgos "Kato Lakkos" (Figure 8) are relatively characteristic for that period in size and form [31]. Moreoever, standard features were the elongated cisterns at the lower edge of inclined runoff surfaces inside settlements, such as Monemvasia or Great Castle on Kalymnos island. However, at the time, the water quality of the potable water was very little improved (e.g., purification and infiltration).
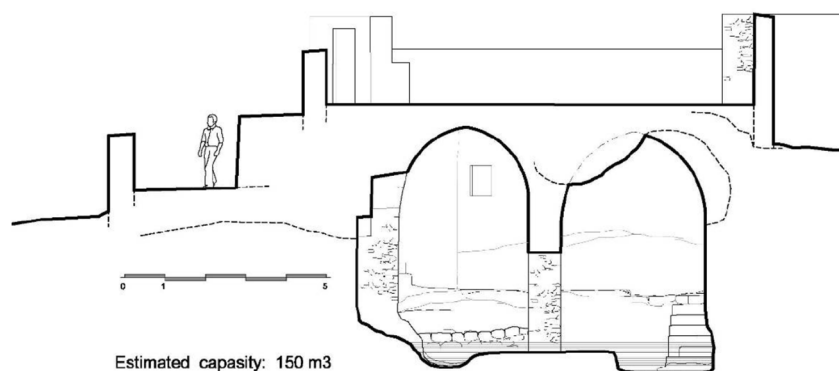

Estimated capacity: 150 m3

Figure 8. Kato Lakkos medieval cistern, Chora Amorgos. Cross section facing north (G. P. Antoniou).

4. Water Quality in Contemporary Times (1900 AD-Present)

In general, in modern times, water is supplied to homes and factories by applying pipes, electrical pumps, and new technologies. The water quality issues that have emerged in the mid-20th century are [23]:

(a) Eutrophication. Not well understood at first. Richard Vollenweider [32] in the late 1960s was credited with making the connection between eutrophication and nutrients.
(b) Aging water treatment facilities. Most facilities were built in the 1920s and 1930s; they reached their design age by the 1950s and provided the impetus to upgrade many facilities.
(c) Water shortages start emerging partially due to pollution problems. New legislation often focused on preserving water quality to increase supply.

During the early contemporary times, historical data showed that life expectancy was shortened due to several infectious diseases, such as pneumonia, tuberculosis, meningitis, etc. Many premature deaths were attributed to them [9]. Kramek and Loh reported an example illustrating this situation in Philadelphia [33], USA; several hundred typhoid deaths occurred in 1900 due to water pollution. Following the completion of a filtration construction in 1912 and the chlorination of the city water supply in 1913, typhoid deaths

were dramatically reduced [9]. This fact demonstrates that there is a direct connection between sanitation measures and human health and, furthermore, that technological progress is extremely beneficial for humankind (Figure 9).
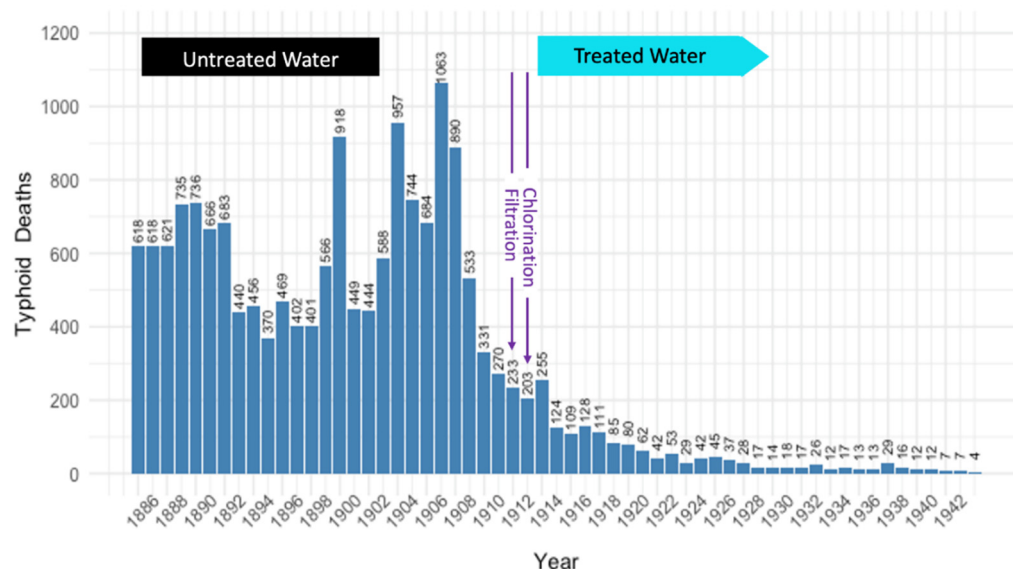

Figure 9. The number of typhoid deaths in Philadelphia was drastically reduced following the city-wide water filtration (1912) and chlorination (1913) system. Data from the Philadelphia Water Department Collection (Adapted from [33]).

Historical data from England and Wales show a remarkable increase in life expectancy between 1850 and 1930, which reached almost 20 years. Thus, life expectancy from 40 years for males and 42 for females in 1851 reached 59 and 63 years in 1930, respectively. This striking improvement was recorded before the discovery of antibiotics and it must be attributed to other factors (Office for National Statistics, 2015). Moreover, in Greece, life expectancy in 1920—24 was 45 years, mainly due to the low quality of available water supply. However, in most developed countries of the world, the quality of drinking water improved significantly after the 1st World War. In Greece, the life expectancy reached 83 years in 2021. However, there has been a small decrease in the last years due to the pandemic of COVID-19.

In the European Union (EU), in 2000, the Water Framework Directive (WFD) with the title "Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy" was adopted. The WFD required, among other things, for the EU Member States to assess water management status and the quality of water resources by using a plethora of water quality-related parameters (e.g., specific nutrients and organic compounds). The overall collection of the data from each Member State created the Water Information System for Europe–Water Quality database (European Environment Agency, 2020). This EU effort is supported by other synergetic directives targeted at protecting the EU water bodies and to help them reach the "good status" by 2027 at the latest, such as the Urban Waste Water Treatment Directive (UWWTD) (91/271/EEC) [34] and the "Nitrate Directive", acting under the WFD, 91/676/EEC *concerning the protection of waters against pollution caused by nitrates from agricultural sources* [35]. The main goals of the Nitrate Directive are to identify the nitrate-polluted waters across the EU Member States and to produce the corresponding Nitrates Vulnerable Zones (NVZ) with a significant contribution to pollution by agriculture as well as to develop action programs targeted at reducing or preventing such nitrate pollution within NVZ or a wider territory. The commission is obligated to inform the European Parliament and the Council periodically (every four years) on the implementation of the Directive by Member States.

In regards to UWWTD, the directive concerns "the collection, treatment and discharge of urban waste water and the treatment and discharge of waste water from certain industrial sectors". Moreover, the EU released guidelines for effluent reuse, proposing minimum requirements regarding the agricultural irrigation and aquifer recharge as well as monitoring actions [36]. Moreover, the criteria are proposed to define different water quality classes, depending on the use of crops and the irrigation method used, based on BOD/COD thresholds and *E. coli* population (10 up to 10,000 cfu/100 mL), as well as limits for specific parameters, including heavy metals, pesticides, disinfection byproducts, pharmaceuticals, other substances of emerging concern, and antimicrobial resistance [37].

In Greece, an EU member, water resources management is covered by the 3199/2003 national law and the 5/2007 presidential decree, established to achieve synchronization with the EU WFD; this directive, among others, established water management plans for the 14 river basin districts (RBD) of Greece to protect water resources. For example, for the RBD of Crete, the first water management plan was released in 2015 [36], followed by the first revision in 2017, covering the period of 2016 to 2021 [38]. Previously, in 2011, the Common Ministerial Decision (CMD) was released by the Greek government to introduce measures, limits, and procedures for the reuse of treated wastewater [39].

In the USA, disinfection has contributed significantly to the improvement of drinking water quality. In 1908, Jersey City, New Jersey was the first American city that began the disinfection of community drinking water on a regular basis. Over the next decade, thousands of cities and towns applied this method, and this contributed to a drastic decrease in morbidity in the country (Figure 10). The Federal Water Pollution Control Act was adopted in 1948 in the USA; it was the first significant law to address water pollution. Public awareness and concern about water pollution increased and led to drastic amendments in 1972 [40]. Since the 1972 amendment, the law is commonly known as the Clean Water Act (CWA) [9]. In the USA, a death rate per 100,000 inhabitants per year due to water-related infectious diseases from 1900 to 1996 was developed. After the mid-20th century, the cases of cholera and typhoid fever dropped dramatically, while the occurrence of typhoid fever was approximately 100 cases per 100,000 people. By 1920, it had dropped to 33.8, and in 2006 it was only 0.1 (353 cases total) [41]. Approximately 75% of these cases occurred among international travelers. The disease became rare, especially in cities where water disinfection was combined with improvements in sanitation, hygiene, and the overall upgrading of public health [9].

(**a**)   (**b**)

Figure 10. Greek WTPs: (**a**) In Galatsi Athens (Photo G. Stefanakou, EYDAP, Athens, Greece), and (**b**) the Thessaloniki Water Treatment Facility (Refinery) (www.eyath.gr, assessed 1 March 2022).

In Greece, a similar approach was applied. In Athens, the capital city of the country, water for drinking and domestic demands is supplied mainly from surface water reservoirs (Marathonas, Yliki, Mornos, and Evinos). Groundwater via boreholes is also used for

water supply (www.eydap.gr, assessed 1 March 2022). In Athens, the first Water Treatment Plan (WTP) was implemented in December of 1931 in Galatsi (Figure 10a), with two major innovations for the disinfection of water with chlorine and the use of aluminium sulphate to accelerate water clarification. The unit was expanded successively in 1952 and 1964, and it is located at an altitude of 159 m. Its refining capacity is about 540,000 m^3 per day of water and supplies the center of Athens and the Municipality of Piraeus.

In Thessaloniki (the second biggest city in Greece), in 1917, the Hellenistic times' aqueduct Chortiatis was restored, and the first WTP was implemented in which calcium hypochlorite was used [31]. Today, the city's domestic water needs (250,000 m^3 per day) are met by using the karst spring of Aravisos and the reservoir on the Aliakmonas river (Figure 10b). Thereafter, Water Municipal Enterprises (DEYA) were established in most cities all over the country. Moreover, in most of the WTPs, chlorine is used for disinfection.

Water quality is not the only factor affecting quality of life and life expectancy. Other factors concern child mortality, diseases, medicines, pharmacology, nutrition, environmental and other risks, etc., and standards of life. However, some authors (e.g., [9,42,43] suggest that water quality is the main factor that has led to the increase in life expectancy during the last century (from 30 years to over 80). It must be pointed out that, since prehistoric times, life expectancy was ca. 30 years. In Greece, during the Minoan Era (ca.5000—3000 years ago), life expectancy was a little less than 30 years old, in the Classic and Hellenistic period (ca. 2500—2100 years ago) it hardly passed 30 years, and after the 1st World War, it reached 45 years [9]. Moreover, in a special edition of V. Kotzamanis, it is mentioned that the average life expectancy of the Greeks in the 19th century was about 36 years. Within about thirty-five years, the expectation of survival was extended after the 2nd World War, and it reached 65 years in the period 1955–1959 [44]. Life expectancy increased in 1959 for both sexes to 63, 4 years and 70.1 years for men and women, respectively. After 40 years, i.e., in 1999, they increased to 75.5 years and 80.6 years, for men and women, respectively [44]. Currently, it is 84 for women and 81.5 for men, with an increasing trend. Such a dramatic increase in life expectancy after the 2nd World War is probably due to improved potable water quality and hygiene conditions [9]. However, life expectancy from 2019 to today was slightly reduced due to the pandemic of COVID-19 [45].

According to data released by the Prolepsis Institute, which is a joint effort of the Organization for Economic Co-operation and Development (OECD) and the European Monitoring Center for Health Systems and Policies in cooperation with the European Union (EU), the life expectancy of Greeks is slightly higher than the EU average. However, there are still inequalities in terms of health by gender and social status [46].

5. Water Quality: Emerging Trends and Future Issues and Challenges

Global freshwater needs for agriculture, industry, and domestic use have increased from 500 billion m^3/year in 1900 to over 4 trillion m^3 today. This depicts the growing world population. According to the UN, the world's population is currently growing by approximately 1.1% per year and is expected to reach between 9.4 and 10.1 billion by 2050 [47]. As the anticipated growth of population is expected to occur mainly in developing low-income countries (LICs), such as those of sub-Saharan Africa, where the lack of suitable infrastructure and limited economic resources and access to technology coexist [48], an increased pressure for the quantity and quality of water resources is to be expected. Describing the current situation based on a WHO report [48], (a) 2.1 billion people globally do not have access to clean and safe drinking water, (b) 3.4 million people die each year due to contaminated and scarce water sources, (c) millions of women and children spend 3–6 h each day in order to collect water from distant polluted sources, (d) in the developing countries, people walk for an average distance of 6.00 km to reach clean water, and (e) half of the world's hospital beds are constantly occupied by patients who suffer from diseases associated with the lack of access to clean water. Options to preserve water quality in the LICs may include cost-efficient and household-centered sanitation systems [49,50] inspired and developed on the basis of old techniques, some of which have

been described in this study. Moreover, where it is affordable, the building of an extensive network of sewages and (waste) water treatment plants should be considered. On a global scale, improved water management and treatment and the use of nonconventional water resources have been proposed, also applying cost and water-efficient practices by the users (i.e., domestic, agriculture and industry) [51].

A recent study has summarized the most important emerging trends and challenges to deal with the new 21st century water realities [6], including mainly: (a) the need to consider all potential sources of water for potable use, (b) to update conventional water treatment practices to remove all the old and emerging pollutants and contaminants, (c) to move from the linear to the cyclic model of water use (i.e., to introduce circular economy practices), (d) to develop an ongoing effective risk management program considering reliability, robustness, and resilience concepts, (e) to design and implement voluntary and mandatory water conservation measures (e.g., the use of low-flow fixtures, alternate landscape watering days, and replacement of lawns with desert-type landscaping), (f) to develop effective operating strategies for aging water distribution networks to protect public health, and (g) to develop integrated regionwide sustainable water resource management programs, implemented and assessed in the context of a long-term water management strategy [6].

5.1. Water Quality and Water Scarcity

Water scarcity is a critical issue in many regions of the world, describing the lack of available water resources for ecosystems and human purposes. Water scarcity usually refers to water quantity, however, water quality is also a contributor to overall water supply as it affects the usability of water and the potential damages to the functioning and services of ecosystems [52–54] caused, e.g., by sthe preading of organic pollutants, contaminants, nutrients, etc. A recent global study indicates an increased percentage of people affected by severe water scarcity from 30 to 40% when water quality is accounted for [52]. Reversely, water scarcity can impact water quality by the measures applied to increase the available water [52]. Some examples consist of the overexploitation of surface water resources and groundwater, as well as the use of nonconventional water resources which may pose a risk for water quality and threaten biodiversity and human health, discussed in Sections 5.2 and 5.3 below.

Increased drought events due to changes in climate characteristics may further exacerbate water scarcity and water supply and constitute both currently and in the future a crucial challenge for climate-vulnerable areas of the planet (e.g., the Mediterranean basin and Greece) [55,56]. An opposite effect of climate change includes intensive precipitations causing extreme hydrological events and the spreading of pollutants (organics, nutrients, metals, etc.)/contaminant patterns impairing water quality [57,58]. Such impairment in water quality, with regard to nutrients and eutrophication, affects the ecosystems and humans; for blooms in the U.S., the annual cost has been estimated up to USD 4 billion [59]. Overall, both climate-induced changes in the quantity and quality of water reduce water availability and corroborate water scarcity.

A crucial future challenge for water agencies in Greece and other similar areas of the planet is to deal with the impact of climate change on water supply sources. In climate conditions such as sustained dry and wet weather periods and rainfall intensity, predictions based on past hydrological data may fail because these are no longer representative given the current climate variability. Moreover, several issues must be addressed, such as the construction of new water facilities that may not fill, the use of advance treated wastewater for groundwater and surface water increase, and the revision of existing infrastructure operating rules. Due to climate change, wet areas become wetter and dry areas become drier but, most importantly, rainfall is very intense. Most existing treatment systems were not designed to operate under very intense rainfall events. There is no consensus as to the appropriate approach that will allow the integration of climate change impact in the setting up of future strategies in water portfolio management. In the scientific field, we need to change the scale of our perspective regarding the interplay between climate and water

quality, from the local one to a wider (global) view, as well as to gain insights in climate and water quality monitoring in space and time along with the use of commonly accepted methodologies and sets of water quality parameters [59].

5.2. Water Quality and Use of Nonconventional Water Resources

Today, the use of good-quality nonconventional water resources is ideal either for water scarcity and climate-change-vulnerable areas of the plant, such as the Mediterranean basin, or for population-developing areas to increase water availability, protect water resources, and support the economy [60]. The challenge is, however, to gain the projected benefits without causing damage to water quality or even preventing the risk to human health. Therefore, we need developments in treatment technology as well as regulatory actions against the spreading of specific pollutants and contaminants and several social–economic constraints [51,61].

Developing new water resources is complex and thus, at the local scale, most municipalities' agencies acknowledge that water use (including planned potable water reuse) can contribute decisively to alleviating water shortage issues. However, in many cases, the location of most wastewater treatment plants (WWTPs) does not allow water reuse opportunities. There are several impediments to potable and nonpotable reuse, such as infrastructure costs and social disruption associated with the transport and storage of advanced treated water to or near the point of use. In order to address the unintended consequences of wastewater treatment plant location, integrated wastewater management systems should be developed employing satellite treatment plants at upstream locations. The key feature of these plants is that all solids are returned to the collection for treatment at existing treatment plants. Without the need for solids processing, the performance of satellite plants can be optimized for specific water reuse opportunities [62].

In many coastal regions, desalination is also an option to increase existing water supply sources, particularly in big or megacities. In this case, also, the challenge will be to introduce desalinated water into an existing water distribution system without causing any unintended water quality problems [63]. Small-scale desalination plants and the combined use of the sea and brackish water would also be of concern for the near future for these areas [60,64].

Another option includes rain harvesting (RH), which appears to be one of the most promising alternatives for supplying fresh water in the face of increasing water scarcity and escalating demand, especially in unpolluted areas. In Greece, previous analyses of the rainwater samples showed that rainwater quality was within the guidelines for chemical parameters established by the EU directives. However, the potable use of RH requires previous microbiological and physicochemical analysis of the water. RH is still unknown in many areas of Greece, such as in Crete; however, similar options, such as collecting greenhouse rainwater, have been considered [65]. Overall, RH is a promising technology to save water in areas with increasing water demands; however, there are still issues and challenges that need to be resolved in technology, urban and water planning, policy, economy, and health [23].

5.3. Water Quality and Emerging Pollutants/Contaminants (e.g., Pathogens, Pharmaceuticals, and Microplastics)

Waterborne pathogens are and will be a challenge for human health, triggered by several synergetic factors, such as increasing population and urbanization, climate change and/or variability, water reuse practices, disasters, traveling, ecosystem disturbances, lack of awareness and education, and economy [66,67]. Known cholera and several other pathogens are still threats for people [68,69], particularly in developing countries, due to the cost of water treatment [70,71]. For rural areas, the idea of prevention at source [72,73] by applying cost-effective sanitation systems along with household-centered sanitation systems has been proposed [50]. The main challenge that remains in order to reduce waterborne diseases worldwide is to elucidate the contribution of each synergetic factor to the dispersion and transmission of diseases and the underlying mechanisms and processes

linking pathogens to human hosts, a challenge related to scale-dependent processes and the diversity of pathogens [74–77].

Emerging pollutants and contaminants include disinfection byproducts, pharmaceuticals and Personal Care Products (PPCPs), and antimicrobial resistance, which are commonly found in municipal wastewater effluents [78,79], or even microplastics [80,81], found in terrestrial and aquatic environments [82–84]. These substances, through the trophic chain, also threaten biodiversity and risk humans' health [85–87]. An essential category of pollutants are the endocrine-disrupting compounds (EDCs) that can impair plant growth and soil microorganisms [88,89]. EDCs have been identified so far in domestic effluents, sludge/biosolids, industrial wastewaters, landfill effluents, and livestock wastes [90,91].

Antibiotics and antibiotic resistance have been recognized by the World Health Organization (WHO) as the most critical public health issue of the 21st century. The main reservoirs of antibiotics and antibiotic resistance genes (ARGs) are wastewater treatment units, known as wastewater treatment plants (WWTPs), which originated from the presence of incompletely metabolized antibiotics in human excretions [84,92] being transferred to aquatic environments [93–95]. In nature, antibiotic resistance can spread either by antibiotics' distribution or by transferring ARGs between bacteria via conjugation, a microbial-specific process [78,92,96–98]. Future work should focus on effective tertiary treatment methods and on the practices/mechanisms/processes driving ARGs' transfer source to the environment (aquatic and soil) and from the environment to animals and humans [84].

Large amounts of plastics, in the form of a variety of products, such as industrial and pharmaceutical products, are discharged into the environment; there are estimates of 4900×10^6 tons of plastics discarded so far in the environment and landfills, with 600×10^6 tons as polyester, polyamide, and acrylic fibers [99]. A part of the plastic debris and microplastics (<5 mm), also found in wastewater treatment plants, may end up in terrestrial and aquatic ecosystems, threatening biodiversity, such as fish, animals, plants and micro-organisms, and ecosystems' functioning and services [81,100–102],risking human health [103–105]. Moreover, due to their size and chemical properties, microplastics may act as a carrier of specific pollutants (e.g., organic pollutants or heavy metals) or even contaminants (e.g., bacteria), further impairing the environment [81,83,102,106]; there are recently published studies showing that microplastics are capable of carrying different substances in aquatic environments, such as anionic dye [80], antibiotics [107], and nitrates [108]. The research area of microplastics is still virgin, so there are many challenges in the domains of quantitative analysis of various environmental samples or of a unified methodology towards an improved microplastics traceability and assessment of their fate in the environment, plants, animals, and humans. Much effort also should be conducted on the domain of policy and regulatory actions by developing and implementing an adequate legislative framework to control the production and spreading of microplastics into the environment [103].

6. Conclusions

The consideration of water quality used for drinking and other purposes has been ongoing since prehistoric times. Purification technologies (e.g., filtration, sedimentation, and decontamination) were developed and applied by ancient civilizations, producing different qualities of water delivered to satisfy appropriate purposes; water of poor quality was intended for industrial processes or watering gardens, while better water was reserved for drinking. The prehistorian Greeks and Indian civilizations were among the first considering water quality, constructing tanks and other devices to treat water. These civilizations were also able to reuse water by applying primitive rain harvesting techniques to water supply; the latter was solely dependent on atmospheric precipitation. During historical times (ca. 750 BC–476 AD), archaeological excavations and historical information provide evidence of water hydro-technologies, such as aqueducts, dams, water networks, and other sanitary and purification structures (e.g., sand, ceramic, or cloth-based filters to treat water) as well as special laws defining their use. Roman times (ca. 31 BC–476 AD) improved

these hydro-technologies of the Hellenistic period, mainly by increasing their scale. During medieval times (ca. 476–1400 AD), a period also known as the Dark Ages, the technological development, especially those related to water quality, was minimal due to the lack of scientific innovations and experiments. After the fall of the Roman Empire enemy forces, many aqueducts and other water technologies were destroyed and were no longer applied. During early and midmodern times (ca. 1400–1900 AD), the interest in sanitation and the protection of water quality and human health increased progressively, as indicated by archeological and historical evidence (e.g., technological constructions of Venetians).

Since the beginning of the 20th century, drinking-water supply safety is of paramount importance for human health. Disinfection is considered as one of the most significant water treatment processes as it inactivates most pathogens. However, disinfection, especially chemical, usually results in the formation of chemical byproducts (WHO, 2022). Many predictive models and optimization tools have been developed in the research. However, an early warning system integrating monitoring, modelling, and optimization tools is lacking. The disinfection methods and the models developed so far, which present the basic principles for the development of an early warning system, are considered by Tsitsifli and Kanakoudis [109]. It should be mentioned that the WHO has developed guidelines for drinking-water quality in which filtration and disinfection processes are highly considered [110].

During modern times (1900 AD to present), the protection of water quality became a critical issue; new water technologies in the domains of water purification and wastewater treatment as well as other synergetic technologies (e.g., sewages, pipes, electrical pumps, etc.) were developed. However, since the mid-20th century, new water quality issues have emerged, such as eutrophication, improvement of water treatment facilities, and water pollution problems from chemical and microbiological substances. Legislation often focused on preserving water quality as a means of increasing supply. Currently, water quality is still considered an increasing challenge for scientists and governments, induced mainly by a growing population and lack of resources and infrastructure (mostly in developing countries), the use of nonconventional water resources and the spreading of "new" emerging pollutants and contaminants (e.g., antibiotics and microplastics), and climate change and/or variability. Against the old and new challenges in water quality, humankind's experience has led to strategies and measures to protect water quality and maintain water supplies for the future. Such actions, in the context of the present study, can be summarized as follows:

- Revisit and recognize the chronological evolution of water quality technologies as an essential guarantee against water quality and life preservation through the ages;
- Revise water resource management programs within an integrated and holistic approach where local and regional-scale particularities and needs are considered in the context of a long-term water management strategy;
- Consider nonconventional water resources even for potable use (e.g., water reuse, rainwater harvesting, stormwater utilization, and desalination), particularly in climate change/water scarcity vulnerable and/or rapidly and densely growing areas (e.g., megacities) as a mean to increase water availability and protect the sustainability of natural resources;
- Consider and remove the old and new emerging pollutants and contaminants (e.g., antibiotics and microplastics) by updating the current water and wastewater treatment technologies;
- Include nonconventional water resources within a cyclic model of water use in agreement with the requirements of the circular bioeconomy concept;
- Provide links between climate change and water quality; it is required to understand how climate change alters the precipitation and temperature patterns and how these changing climate parameters influence the transfer and spreading of pollutants/contaminants to water bodies and even to biodiversity and humans;

- Change the scale of our view regarding the interplay between climate and water quality, from the local one to a broader (global) view and improve climate and water quality monitoring in space and time (use of commonly accepted methodologies and a set of representative water quality parameters);
- An alternative may include the so-called "risk management focus", which consists of proactively aiming at preventing and mitigating drought impact. These measures focus on identifying the sources of vulnerability (sectors, regions, communities, or population groups) to implement mitigation and adaptation actions to future droughts.

Finally, it should be mentioned that a lot of hygeonologist scientists have reported that the strength of the relationship between life expectancy and life span equality is not coincidental but rather a result of progress in saving lives at specific ages: the more lives saved at the youngest ages, the stronger the relationship is [111]. In addition, Stanford researchers found that a reduction in child mortality is a key driver in the declining lifespan inequality gap in wealthy countries, including the United States, Canada, France, Germany, Italy, Japan, and the United Kingdom [112].

References

1. Mays, L.W. A brief history of water filtration/sedimentation. *Water Supply* **2013**, *13*, 735–742. [CrossRef]
2. Kosso, C.; Scott, A. *The Nature and Function of Water, Baths, Bathing, and Hygiene from Antiquity through the Renaissance*; Brill: Leiden, The Netherlands, 2009; Volume 11.
3. Zarkadoulas, N.; Koutsoyiannis, D.; Mamassis, N.; Papalexiou, S. Climate, water and health in ancient Greece. In *Climate, Water and Health in Ancient Greece*; European Geosciences Union General Assembly, Ed.; European Geosciences Union: Munich, Germany, 2008; p. 10.
4. Angelakis, A.; Koutsoyiannis, D.; Tchobanoglous, G. Urban wastewater and stormwater technologies in ancient Greece. *Water Res.* **2005**, *39*, 210–220. [CrossRef] [PubMed]
5. Koutsoyiannis, D.; Patrikiou, A.; Ostigard, T. Water control in Ancient Greek cities. *Water Urban.* **2013**, 130–148.
6. Angelakis, A.; Voudouris, K.; Tchobanoglous, G. Evolution of water supplies in the Hellenic world focusing on water treatment and modern parallels. *Water Supply* **2020**, *20*, 773–786. [CrossRef]
7. Mays, L.W.; Sklivaniotis, M.; Angelakis, A.N. Water for human consumption through the History. In *Evolution of Water Supply through the Millennia*; Angelakis, A.N., Mays, L., Eds.; IWA Publishing: London, UK, 2014; Chapter 2; pp. 19–42.
8. De Feo, G.; Mays, L.; Angelakis, A. Water and wastewater management technologies in the ancient Greek and Roman civilizations. In *Water-Quality Engineering*; Elsevier: Amsterdam, The Netherlands, 2011; pp. 3–22.
9. Angelakis, A.N.; Vuorinen, H.S.; Nikolaidis, C.; Juuti, P.S.; Katko, T.S.; Juuti, R.P.; Zhang, J.; Samonis, G. Water quality and life expectancy: Parallel courses in time. *Water* **2021**, *13*, 752. [CrossRef]
10. Angelakis, A.N.; Spyridakis, S.V. The status of water resources in Minoan times—A preliminary study. In *Diachronic Climatic Impacts on Water Resources with Emphasis on Mediterranean Region*; Angelakis, A., Issar, A., Eds.; Springer-Verlag: Heidelberg, Germany, 1996; pp. 161–191.
11. Smith, V.S. *Clean: A History of Personal Hygiene and Purity*; Oxford University Press: Oxford, UK, 2008; p. 457.
12. Ashenburg, K. *The Dirt on Clean: An Unsanitized History*; North Point Press: New York, NY, USA, 2010; p. 368.
13. Juuti, P.S.; Katko, T.; Vuorinen, H. *Environmental History of Water*; IWA Publishing: London, UK, 2007.
14. Angelakis, A. Evolution of rainwater harvesting and use in Crete, Hellas, through the millennia. *Water Sci. Technol. Water Supply* **2016**, *16*, 1624–1638. [CrossRef]
15. Krasilnikoff, J.; Angelakis, A.N. Water management and its judicial contexts in ancient Greece: A review from the earliest times to the Roman period. *Water Policy* **2019**, *21*, 245–258. [CrossRef]
16. Khan, S.; Dialynas, E.; Kasaraneni, V.; Angelakis, A. Similarities of Minoan and Indus Valley hydro-technologies. *Sustainability* **2020**, *12*, 4897. [CrossRef]

17. Baker, M.N.; Taras, M.J. *The Quest for Pure Water: The History of Water Purification from the Earliest Records to the Twentieth Century*, 2nd ed.; American Water Works Association: Denver, CO, USA, 1981; Volume 1–2.

18. Sklivaniotis, M.; Angelakis, A. Historical development of the treatment of potable water. In Proceedings of the 1st IWA International Symposium on Water and Wastewater Technologies in Ancient Civilizations, Iraklion, Greece, 28–30 October 2006; pp. 659–666.

19. Defner, M. Late Minoan water treatment device. *Archaeol. Newsp.* **1921**, *8*.

20. Vuorinen, H.S. Water and Health in Antiquity: Europe's Legacy. In *Environmental History of Water—Global Views on Community Water Supply and Sanitation*; Juuti, P., Katko, T., Vuorinen, H., Eds.; IWA Publishing: London, UK, 2007; pp. 45–67.

21. Angelakis, A.N.; Antoniou, G.P.; Yapijakis, C.; Tchobanoglous, G. History of Hygiene Focusing on the Crucial Role of Water in the Hellenic Asclepieia (i.e., Ancient Hospitals). *Water* **2020**, *12*, 754. [CrossRef]

22. Klingborg, P.; Finné, M. Modelling the freshwater supply of cisterns in ancient Greece. *Water Hist.* **2018**, *10*, 113–131. [CrossRef]

23. Angelakis, A.N.; Valipour, M.; Ahmed, A.T.; Tzanakakis, V.; Paranychianakis, N.V.; Krasilnikoff, J.; Drusiani, R.; Mays, L.; El Gohary, F.; Koutsoyiannis, D. Water conflicts: From ancient to modern times and in the future. *Sustainability* **2021**, *13*, 4237. [CrossRef]

24. Yapijakis, C. *Athenian Plague and Coronavirus*; Newspaper the VIMA 6/04/2020: Athens, Greece, 2020. (In Greek)

25. Enzler, S. History of Water Treatment. 1998. Available online: www.lenntech.com/history-wtare-treatment.htm (accessed on 1 June 2022).

26. Al-Shaar, M. Water Sterilization Technology in Muslim Civilization. Muslim Heritage. Available online: https://muslimheritage.com/water-sterilization-technology/ (accessed on 1 June 2022).

27. Rogers, J.R. *Environmental and Water Resources*; American Society of Civil Engineers: Reston, VA, USA, 2007.

28. Foil, J.L.; Cerwick, J.A.; White, J.E. Collection systems past and present. In *Water Environment and Technology*; Water Environment Federation: Alexandria, VA, USA, 1993.

29. Panagiotakis, N.; Angelakis, A.; Koutsoyiannis, D. Water management in the pediada region in central crete through time. In Proceedings of the 1st IWA International Symposium on Water and Wastewater Technologies in Ancient Civilizations, National Foundation for Agricultural Research, Institute of Iraklion, Iraklion, Greece, 28–30 October 2006; pp. 271–280.

30. Spanakis, S. *The Water Supply of Iraklion*; The Technical Chamber of Greece Dept. of Eastern Crete: Iraklion, Greece, 1981; pp. 828–1939.

31. Yannopoulos, S.; Antoniou, G.; Kaiafa-Saropoulou, M.; Angelakis, A. Historical development of rainwater harvesting and use in Hellas: A preliminary review. *Water Sci. Technol. Water Supply* **2017**, *17*, 1022–1034. [CrossRef]

32. Mosello, R.; de Bernadi, R.; Ravera, O.; Richard, A. Vollenweider: Contribution to our knowledge of Italian lakes. *Aquat. Ecosyst. Health Manag.* **2011**, *14*, 174–178. [CrossRef]

33. Kramek, N.; Loh, L. The History of Philadelphia's Water Supply and Sanitation System. Lessons in Sustainability of Developing Urban Water Systems. Master's Thesis, University of Pennsylvania, Philadelphia, PA, USA, 2007.

34. Directive, E. Council Directive of 21. May 1991 concerning urban waste water treatment (91/271/EEC). *J. Eur. Commun* **1991**, *34*, 40.

35. Directive, C. Concerning the protection of waters against pollution caused by nitrates from agricultural sources. *Off. No J. Eur. Communities* **1991**, 375. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31991L0676 (accessed on 10 June 2022).

36. CMD. Common Ministerial Decision. In *Management Plan as a River Basin of the Water Region of Crete*; No 163; ΦΕΚ 570/B′/2015; Ministry of Environment, Energy and Climate Change: Athens, Greece, 2015. (In Greek)

37. EC-COM. European Commission. Proposal for a Regulation of the European Parliament and of the Council on on Minimum Requirements for Water Reuse (337 final). Available online: ec.europa.eu/environment/water/reuse.htm (accessed on 1 June 2018).

38. CMD. Common Ministerial Decision. In *Management Plan as a River Basin of the Water Region of Crete*; No 896; ΦΕΚ B/4666/2017; Ministry of Environment, Energy and Climate Change: Athens, Greece, 2017. (In Greek)

39. CMD. Common Ministerial Decision. In *Measures, Limits and Procedures for Reuse of Treated Wastewater*; No. 145116; Ministry of Environment, Energy and Climate Change: Athens, Greece, 2011. (In Greek)

40. US-EPA. History of the Clean Water Act. Available online: https://www.epa.gov/laws-regulations/history-clean-water-act (accessed on 10 June 2022).

41. Control CfD, Prevention. A century of US water chlorination and treatment: One of the ten greatest public health achievements of the 20th century. *MMWR. Morb. Mortal. Wkly. Rep.* **1999**, *48*, 621–629.

42. Dietrich, A.M. Aesthetic issues for drinking water. *J. Water Health* **2006**, *4*, 11–16. [CrossRef]

43. Reiter, P. Imperatives for urban water professionals on the pathway to 2050: Adapting to rapidly changing conditions on a crowder planet. *Int. Water Assoc. Water Her. Learn Your Peers* **2012**, *4*, 6–8.

44. Kotzamanis, V. *The Evolution of the Life Expectancy of the Greeks*; University of Thessaly: Volos, Greece, 2010; Available online: https://www.flash.gr/tech/1112142/i-exelixi-toy-prosdokimoy-zwis-twn-ellinwn (accessed on 1 June 2022).

45. Anonymous. To 2020, Life Expectancy Fell More than Any Other Year after World War II (In Greek). Available online: https://www.amna.gr/health/article/588471/To-2020--to-prosdokimo-zois-meiothike-perissotero-apo-kathe-alli-chronia-meta-ton-B-Pagkosmio-Polemo- (accessed on 1 March 2021).

46. Angelopoulou, A. The life expectancy of Greeks is a little higher than that of EU citizens. In *Newspaper Naftemporiki*; Zofrank Holdings Co. Ltd.: Athens, Greece, 28 January 2020. (In Greek)

47. Desa, U. *World Population Prospects 2019: Highlights. New York (US)*; United Nations Department for Economic and Social Affairs: New York, NY, USA, 2019; Volume 11, p. 125.

48. WHO. Our Mission. Available online: https://wholives.org/our-mission/mission/# (accessed on 1 June 2022).

49. Mishra, B.K.; Kumar, P.; Saraswat, C.; Chakraborty, S.; Gautam, A. Water security in a changing environment: Concept, challenges and solutions. *Water* **2021**, *13*, 490. [CrossRef]

50. Schwarzenbach, R.P.; Egli, T.; Hofstetter, T.B.; Von Gunten, U.; Wehrli, B. Global water pollution and human health. *Annu. Rev. Environ. Resour.* **2010**, *35*, 109–136. [CrossRef]

51. Tzanakakis, V.A.; Paranychianakis, N.V.; Angelakis, A.N. Water Supply and Water Scarcity. *Water* **2020**, *12*, 2347. [CrossRef]

52. van Vliet, M.T.; Jones, E.R.; Flörke, M.; Franssen, W.H.; Hanasaki, N.; Wada, Y.; Yearsley, J.R. Global water scarcity including surface water quality and expansions of clean water technologies. *Environ. Res. Lett.* **2021**, *16*, 024020. [CrossRef]

53. Brooks, B.W.; Lazorchak, J.M.; Howard, M.D.; Johnson, M.V.V.; Morton, S.L.; Perkins, D.A.; Reavie, E.D.; Scott, G.I.; Smith, S.A.; Steevens, J.A. Are harmful algal blooms becoming the greatest inland water quality threat to public health and aquatic ecosystems? *Environ. Toxicol. Chem.* **2016**, *35*, 6–13. [CrossRef]

54. Carr, G.M.; Neary, J.P. *Water Quality for Ecosystem and Human Health*; UNEP/Earthprint: Nairobi, Kenya, 2008.

55. Cramer, W.; Guiot, J.; Fader, M.; Garrabou, J.; Gattuso, J.-P.; Iglesias, A.; Lange, M.A.; Lionello, P.; Llasat, M.C.; Paz, S. Climate change and interconnected risks to sustainable development in the Mediterranean. *Nat. Clim. Chang.* **2018**, *8*, 972–980. [CrossRef]

56. Kloos, J.; Gebert, N.; Rosenfeld, T.; Renaud, F. Climate change, water conflicts and human security. In *Regional Assessment and Policy Guidelines for the Mediterranean, Middle East and Sahel*; CLICO Final Report; United Nations University–Institute for Environment and Human Security (Report, 10): Bonn, Germany, 2013.

57. Cissé, G. Food-borne and water-borne diseases under climate change in low-and middle-income countries: Further efforts needed for reducing environmental health exposure risks. *Acta Trop.* **2019**, *194*, 181–188. [CrossRef]

58. Semenza, J.C.; Herbst, S.; Rechenburg, A.; Suk, J.E.; Höser, C.; Schreiber, C.; Kistemann, T. Climate change impact assessment of food-and waterborne diseases. *Crit. Rev. Environ. Sci. Technol.* **2012**, *42*, 857–890. [CrossRef]

59. Michalak, A.M. Study role of climate change in extreme threats to water quality. *Nature* **2016**, *535*, 349–350. [CrossRef]

60. Tzanakakis, V.; Angelakis, A.; Paranychianakis, N.; Dialynas, Y.; Tchobanoglous, G. Challenges and Opportunities for Sustainable Management of Water Resources in the Island of Crete, Greece. *Water* **2020**, *12*, 1538. [CrossRef]

61. Paranychianakis, N.; Salgot, M.; Snyder, S.; Angelakis, A. Quality criteria for recycled wastewater effluent in EU-countries: Need for a uniform approach. *Crit. Rev. Environ. Sci. Technol.* **2015**, *45*, 1409–1468. [CrossRef]

62. Tchobanoglous, G. Integrated wastewater management: The future of water reuse in large metropolitan areas. *Integr. Environ. Assess. Manag.* **2019**, *15*, 160–163. [CrossRef] [PubMed]

63. Angelakis, A.N.; Valipour, M.; Choo, K.-H.; Ahmed, A.T.; Baba, A.; Kumar, R.; Toor, G.S.; Wang, Z. Desalination: From Ancient to Present and Future. *Water* **2021**, *13*, 2222. [CrossRef]

64. Voutchkov, N. Energy use for membrane seawater desalination–current status and trends. *Desalination* **2018**, *431*, 2–14. [CrossRef]

65. Demetropoulou, L.; Lilli, M.A.; Petousi, I.; Nikolaou, T.; Fountoulakis, M.; Kritsotakis, M.; Panakoulia, S.; Giannakis, G.V.; Manios, T.; Nikolaidis, N.P. Innovative methodology for the prioritization of the Program of Measures for integrated water resources management of the Region of Crete, Greece. *Sci. Total Environ.* **2019**, *672*, 61–70. [CrossRef]

66. Praveen, P.K.; Ganguly, S.; Wakchaure, R.; Para, P.A.; Mahajan, T.; Qadri, K.; Kamble, S.; Sharma, R.; Shekhar, S.; Dalai, N. Water-borne diseases and its effect on domestic animals and human health: A Review. *Int. J. Emerg. Technol. Adv. Eng.* **2016**, *6*, 242–245.

67. Saravanan, V.; Ayessa Idenal, M.; Saiyed, S.; Saxena, D.; Gerke, S. Urbanization and human health in urban India: Institutional analysis of water-borne diseases in Ahmedabad. *Health Policy Plan.* **2016**, *31*, 1089–1099. [CrossRef]

68. Fenwick, A. Waterborne Infectious Diseases Could They Be Consigned to History? *Science* **2006**, *313*, 1077–1081. [CrossRef]

69. Adegoke, A.A.; Amoah, I.D.; Stenström, T.A.; Verbyla, M.E.; Mihelcic, J.R. Epidemiological evidence and health risks associated with agricultural reuse of partially treated and untreated wastewater: A review. *Front. Public Health* **2018**, 337. [CrossRef]

70. Malik, A.; Yasar, A.; Tabinda, A.; Abubakar, M. Water-borne diseases, cost of illness and willingness to pay for diseases interventions in rural communities of developing countries. *Iran. J. Public Health* **2012**, *41*, 39.

71. Dare, A.M.; Ayinde, I.A.; Shittu, A.M.; Sam-Wobo, S.O.; Akinbode, S.O. Determinants of Cost of Treating Water-Borne Diseases Among Rural Households in South West Nigeria. *J. Adv. Dev. Econ.* **2019**, *1*, 26–38. [CrossRef]

72. Lu, Y.; Song, S.; Wang, R.; Liu, Z.; Meng, J.; Sweetman, A.J.; Jenkins, A.; Ferrier, R.C.; Li, H.; Luo, W. Impacts of soil and water pollution on food safety and health risks in China. *Environ. Int.* **2015**, *77*, 5–15. [CrossRef] [PubMed]

73. Royston, M.G. *Pollution Prevention Pays*; Elsevier: Amsterdam, The Netherlands, 2013.

74. Plowright, R.K.; Sokolow, S.H.; Gorman, M.E.; Daszak, P.; Foley, J.E. Causal inference in disease ecology: Investigating ecological drivers of disease emergence. *Front. Ecol. Environ.* **2008**, *6*, 420–429. [CrossRef]

75. Cohen, J.M.; Civitello, D.J.; Brace, A.J.; Feichtinger, E.M.; Ortega, C.N.; Richardson, J.C.; Sauer, E.L.; Liu, X.; Rohr, J.R. Spatial scale modulates the strength of ecological processes driving disease distributions. *Proc. Natl. Acad. Sci.* **2016**, *113*, E3359–E3364. [CrossRef] [PubMed]

76. Brubacher, J.; Allen, D.M.; Déry, S.J.; Parkes, M.W.; Chhetri, B.; Mak, S.; Sobie, S.; Takaro, T.K. Associations of five food-and water-borne diseases with ecological zone, land use and aquifer type in a changing climate. *Sci. Total Environ.* **2020**, *728*, 138808. [CrossRef]

77. Smith, B.; Fazil, A. Climate change and infectious diseases: The challenges: How will climate change impact microbial foodborne disease in Canada? *Can. Commun. Dis. Rep.* **2019**, *45*, 108. [CrossRef]

78. Karkman, A.; Do, T.T.; Walsh, F.; Virta, M.P. Antibiotic-resistance genes in waste water. *Trends Microbiol.* **2018**, *26*, 220–228. [CrossRef]

79. Suárez, S.; Carballa, M.; Omil, F.; Lema, J.M. How are pharmaceutical and personal care products (PPCPs) removed from urban wastewaters? *Rev. Environ. Sci. Bio/Technol.* **2008**, *7*, 125–138. [CrossRef]

80. Anastopoulos, I.; Pashalidis, I.; Kayan, B.; Kalderis, D. Microplastics as carriers of hydrophilic pollutants in an aqueous environment. *J. Mol. Liq.* **2022**, *350*, 118182. [CrossRef]

81. Baho, D.L.; Bundschuh, M.; Futter, M.N. Microplastics in terrestrial ecosystems: Moving beyond the state of the art to minimize the risk of ecological surprise. *Glob. Change Biol.* **2021**, *27*, 3969–3986. [CrossRef]

82. Ebele, A.J.; Abdallah, M.A.-E.; Harrad, S. Pharmaceuticals and personal care products (PPCPs) in the freshwater aquatic environment. *Emerg. Contam.* **2017**, *3*, 1–16. [CrossRef]

83. Eerkes-Medrano, D.; Thompson, R.C.; Aldridge, D.C. Microplastics in freshwater systems: A review of the emerging threats, identification of knowledge gaps and prioritisation of research needs. *Water Res.* **2015**, *75*, 63–82. [CrossRef] [PubMed]

84. Tan, D.T.; Shuai, D. Research highlights: Antibiotic resistance genes: From wastewater into the environment. *Environ. Sci. Water Res. Technol.* **2015**, *1*, 264–267. [CrossRef]

85. Voulvoulis, N. Water reuse from a circular economy perspective and potential risks from an unregulated approach. *Curr. Opin. Environ. Sci. Health* **2018**, *2*, 32–45. [CrossRef]

86. Xie, J.; Jin, L.; He, T.; Chen, B.; Luo, X.; Feng, B.; Huang, W.; Li, J.; Fu, P.; Li, X. Bacteria and Antibiotic Resistance Genes (ARGs) in PM2.5 from China: Implications for Human Exposure. *Environ. Sci. Technol.* **2019**, *53*, 963–972. [CrossRef] [PubMed]

87. Keerthanan, S.; Jayasinghe, C.; Biswas, J.K.; Vithanage, M. Pharmaceutical and Personal Care Products (PPCPs) in the environment: Plant uptake, translocation, bioaccumulation, and human health risks. *Crit. Rev. Environ. Sci. Technol.* **2021**, *51*, 1221–1258. [CrossRef]

88. Kim, D.; Kwak, J.I.; An, Y.-J. Effects of bisphenol A in soil on growth, photosynthesis activity, and genistein levels in crop plants (Vigna radiata). *Chemosphere* **2018**, *209*, 875–882. [CrossRef]

89. Kwak, J.I.; Moon, J.; Kim, D.; An, Y.-J. Soil ecotoxicity of seven endocrine-disrupting chemicals: A review. *Eur. J. Soil Sci.* **2017**, *68*, 621–649. [CrossRef]

90. Voutsa, D.; Hartmann, P.; Schaffner, C.; Giger, W. Benzotriazoles, alkylphenols and bisphenol A in municipal wastewaters and in the Glatt River, Switzerland. *Environ. Sci. Pollut. Res. Int.* **2006**, *13*, 333–341. [CrossRef]

91. Arditsoglou, A.; Voutsa, D. Occurrence and partitioning of endocrine-disrupting compounds in the marine environment of Thermaikos Gulf, Northern Aegean Sea, Greece. *Mar. Pollut. Bull.* **2012**, *64*, 2443–2452. [CrossRef]

92. Zerva, I.; Alexandropoulou, I.; Panopoulou, M.; Melidis, P.; Ntougias, S. Antibiotic Resistance Genes Dynamics at the Different Stages of the Biological Process in a Full-Scale Wastewater Treatment Plant. *Proceedings* **2018**, *2*, 650. [CrossRef]

93. Yang, Y.; Song, W.; Lin, H.; Wang, W.; Du, L.; Xing, W. Antibiotics and antibiotic resistance genes in global lakes: A review and meta-analysis. *Environ. Int.* **2018**, *116*, 60–73. [CrossRef] [PubMed]

94. Rizzo, L.; Manaia, C.; Merlin, C.; Schwartz, T.; Dagot, C.; Ploy, M.C.; Michael, I.; Fatta-Kassinos, D. Urban wastewater treatment plants as hotspots for antibiotic resistant bacteria and genes spread into the environment: A review. *Sci. Total Environ.* **2013**, *447*, 345–360. [CrossRef] [PubMed]

95. Malakar, A.; Snow, D.D.; Ray, C. Irrigation water quality—A contemporary perspective. *Water* **2019**, *11*, 1482. [CrossRef]

96. Sabri, N.A.; Schmitt, H.; Van der Zaan, B.; Gerritsen, H.W.; Zuidema, T.; Rijnaarts, H.H.M.; Langenhoff, A.A.M. Prevalence of antibiotics and antibiotic resistance genes in a wastewater effluent-receiving river in the Netherlands. *J. Environ. Chem. Eng.* **2018**, *8*, 102245. [CrossRef]

97. Al Salah, D.M.M.; Laffite, A.; Poté, J. Occurrence of Bacterial Markers and Antibiotic Resistance Genes in Sub-Saharan Rivers Receiving Animal Farm Wastewaters. *Sci. Rep.* **2019**, *9*, 14847. [CrossRef]

98. Pazda, M.; Kumirska, J.; Stepnowski, P.; Mulkiewicz, E. Antibiotic resistance genes identified in wastewater treatment plant systems—A review. *Sci. Total Environ.* **2019**, *697*, 134023. [CrossRef]

99. Geyer, R.; Jambeck, J.R.; Law, K.L. Production, use, and fate of all plastics ever made. *Sci. Adv.* **2017**, *3*, e1700782. [CrossRef]

100. Helmberger, M.S.; Tiemann, L.K.; Grieshop, M.J. Towards an ecology of soil microplastics. *Funct. Ecol.* **2020**, *34*, 550–560. [CrossRef]

101. Issac, M.N.; Kandasubramanian, B. Effect of microplastics in water and aquatic systems. *Environ. Sci. Pollut. Res.* **2021**, *28*, 19544–19562. [CrossRef]

102. Enfrin, M.; Dumée, L.F.; Lee, J. Nano/microplastics in water and wastewater treatment processes–origin, impact and potential solutions. *Water Res.* **2019**, *161*, 621–638. [CrossRef]

103. Gong, J.; Xie, P. Research progress in sources, analytical methods, eco-environmental effects, and control measures of microplastics. *Chemosphere* **2020**, *254*, 126790. [CrossRef] [PubMed]

104. Li, J.; Song, Y.; Cai, Y. Focus topics on microplastics in soil: Analytical methods, occurrence, transport, and ecological risks. *Environ. Pollut.* **2020**, *257*, 113570. [CrossRef] [PubMed]

105. Zhou, Y.; Wang, J.; Zou, M.; Jia, Z.; Zhou, S.; Li, Y. Microplastics in soils: A review of methods, occurrence, fate, transport, ecological and environmental risks. *Sci. Total Environ.* **2020**, *748*, 141368. [CrossRef]

106. Kinigopoulou, V.; Pashalidis, I.; Kalderis, D.; Anastopoulos, I. Microplastics as carriers of inorganic and organic contaminants in the environment: A review of recent progress. *J. Mol. Liq.* **2022**, *350*, 118580. [CrossRef]

107. Li, J.; Zhang, K.; Zhang, H. Adsorption of antibiotics on microplastics. *Environ. Pollut.* **2018**, *237*, 460–467. [CrossRef] [PubMed]

108. Spyridakis, I.; Tzanakakis, V.A.; Pashalidis, I.; Kalderis, D.; Anastopoulos, I. Polyamide nylon 6 as a potential carrier of nitrate anions in aqueous environments. *J. Mol. Liq.* **2022**, *352*, 118706. [CrossRef]

109. Tsitsifli, S.; Kanakoudis, V. Disinfection impacts to drinking water safety—A review. *Multidiscip. Digit. Publ. Inst. Proc.* **2018**, *2*, 603.

110. World Health Organization (WHO). *Guidelines for Drinking-Water Quality: Incorporating the First and Second Addenda*; World Health Organization (WHO): Geneva Switzerland, 2022.

111. Aburto, J.M.; Villavicencio, F.; Basellini, U.; Kjærgaard, S.; Vaupel, J.W. Dynamics of life expectancy and life span equality. *Proc. Natl. Acad. Sci.* **2020**, *117*, 5250–5259. [CrossRef]

112. Parker, C.B. Stanford Research Cites Child Mortality as Major Factor in Lifespan Inequality Gap. Stanford News. Available online: https://news.stanford.edu/2016/07/20/stanford-research-cites-child-mortality-major-factor-lifespan-inequality-gap/ (accessed on 1 June 2022).