

Review

The Health of the Water Planet: Challenges and Opportunities in the Mediterranean Area. An Overview

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Abstract: According to the United Nations (2020), since the 1980s, the global overall rate of water use has grown by 1% per year, and it is projected that, by 2050, humanity's water footprint could exceed 30% of current levels. This situation is in stark contrast to the path toward the Sustainable Development Goals, especially Goal 6, "clean water and sanitation", which also influences Goal 14, "life below water", and Goal 15, "life on land". This is because the availability of water directly affects the food security and production capacity of each Country, and therefore its management is a crucial issue worthy of particular attention. Problems related to water security are particularly evident in the Mediterranean area, which is already facing high environmental challenges. It is an area severely affected by global warming; thus, it is one of the most vulnerable environments to climate change globally. It follows that the improper management of water resources could further worsen an already alarming situation. This research aims to study the main water-related challenges that Mediterranean Countries face, highlighting the significant problems that weaken each Country. In this regard, the indicators relating to Goal 6 were considered, to define each Country's current state. However, for a correct understanding, the main problems these Countries face were researched through a critical review of the literature (Scopus, Google Scholar, Web of Science). In this way, we were able to underline the effects of human activities on the hydrosphere and the repercussions on various ecosystems, following the drivers-pressures-state-impact-response causal framework. The results suggest that there is still a long way for Mediterranean Countries to progress toward Agenda 2030, as they face problems related to chemical (nitrate, microplastics, heavy metals, pesticides, etc.) and biological (*E. coli* and other microorganisms) pollution, as well as saline aquifers, absent or obsolete infrastructures, and transboundary basins. Hence, this study aims to provide valuable tools for a better evaluation of water management in Mediterranean Countries.

Keywords: water; water management; Mediterranean Countries; SDGs; sustainability; water quality; water quantity



Citation: Vinci, G.; Maddaloni, L.; Mancini, L.; Prencipe, S.A.; Ruggeri, M.; Tiradritti, M. The Health of the Water Planet: Challenges and Opportunities in the Mediterranean Area: An Overview. *Earth* **2021**, *2*, 894–919. <https://doi.org/10.3390/earth2040052>

Academic Editor: Hossein Bonakdari

Received: 7 October 2021

Accepted: 3 November 2021

Published: 5 November 2021

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1. Introduction

In 2015, the 70th United Nations General Assembly announced the 17 "Sustainable Development Goals (SDGs)", which provide a common framework covering environmental, social, and economic aspects to achieve long-term sustainable development [1]. The Sustainable Development Goals are primarily geared toward eradicating extreme conditions such as poverty and hunger, reducing inequalities, and preserving the earth. Many Countries' social development and economic prosperity strongly depend on water resources and marine ecosystems [2].

Indeed, the inadequate management of these resources could lead to a significant change in aquatic and terrestrial habitats and the quality of life of communities and populations [3].

Water is a determining factor in the location of human settlements, both civil and productive; for socio-economic activities; and for the ecological environment. For these reasons, Goal 6 (water and sanitation for all) explicitly aims at safe and sustainable water management and is also central to achieving all other SDGs [4–6]. Water security improves food security, contributing to Goals 1 (no poverty), 2 (no hunger), and 3 (good health), and facilitates the creation of jobs, contributing to the achievement of Goals 8 (economic growth and decent jobs), 9 (innovation, infrastructure, and industry), and 10 (reduced inequalities). The sustainable management of water resources also facilitates the protection of ecosystems and biodiversity (Goals 14 and 15) [7]. In addition, cooperation over cross-border rivers and groundwater is an opportunity to support stability and peace among urban and rural communities. In this regard, Goal 17 (strengthen the means of implementation and revitalize the global partnership for sustainable development) represents a critical point for the completion of the framework of actions planned for the achievement of all Sustainable Development Goals [8]. According to the United Nations, although access to safe water and basic sanitation is a human right and essential for the food security, health, and hygiene of the population, there are still some very alarming numbers in the world: 844 million people lack access to safe water, 2.4 billion people lack access to basic sanitation, 2 billion people live in regions suffering from high water stress, and 4 billion people suffer from a severe water shortage for at least one month per year [9]. Many communities have limited or completely non-existent access to good quality water due to natural and anthropogenic factors that hinder its supply, use, and quality, generating water insecurity. Hence, in this study, the drivers–pressures–state–impact–response causal framework has been used to evaluate the main factors affecting water management in Mediterranean Countries. From that, this approach considers human activities that put pressure on the environment and consequently impact standards of living. Water losses caused by obsolete or poorly maintained infrastructure and cross-border conflicts negatively affect the quantity, availability, and accessibility of water in specific geographical areas. Another problem involving limited access to water resources is related to water quality. Indeed, a problem identified, which is encountered in many Countries, is the physical, chemical, and biological pollution of water resources. Qualitative and quantitative problems related to water are particularly evident in the Mediterranean region, which includes 24 Countries distributed between Europe, Asia, and Africa. Within these continents, two macro-areas may be classified: Europe (Albania, Bosnia-Herzegovina, Croatia, Cyprus, France, Greece, Italy, Malta, Portugal, Slovenia, and Spain) and the Middle East and North Africa (MENA) (Algeria, Egypt, Jordan, Montenegro, Lebanon, Libya, Morocco, Palestine, Syria, Tunisia, and Turkey). Although not directly bordering the Mediterranean Sea, Portugal and Jordan were included due to their geopolitical influence in the Mediterranean area. The Mediterranean region has a supply of renewable water resources of about 1500 km³, unevenly distributed between the north (74%), the east (21%), and the south (5%) [10]. Furthermore, the Countries in this area are characterized by intense water stress (when more than 40% of available water is withdrawn within a certain region), especially the Countries of the MENA region, which is reflected in the final availability of water. In the coming years, the risk of water stress will increase significantly, affecting the Mediterranean area even more severely. In this regard—by what was said in April 2020 by the Secretary-General of the United Nations (UN): “Today, Sustainable Development Goal 6 is badly off track and is hindering progress on the 2030 Agenda”—this research starts with the evaluation of the progress of Mediterranean Countries toward Goal 6 (although fewer than 50% of the Countries have comparable estimates for most indicators related to Goal 6, making it difficult to determine the progress). In particular, the databases “Aquastat”, “The SDG 6 data portal”, and “The global JMP database” were used. Moreover, for a more complete evaluation, indicators 6.1.1 (“Proportion of population using safely managed drinking water services”), 6.2.1 (“Proportion of population using (a) safely managed sanitation services and (b) a hand-washing facility with soap and water”), 6.3.1 (“Proportion of domestic and industrial wastewater flows safely treated”), 6.4.1 (“Change in water-use efficiency

over time”), 6.4.2 (“Level of water stress”), 6.5.1 (“Degree of integrated water resources management”), 6.5.2 (“Proportion of transboundary basin area with an operational arrangement for water cooperation”), and 6.6.1 (“Change in the extent of water-related ecosystems over time”) were taken into consideration for each Country to evaluate their recent water management (the only data available related to these indicators was for the year 2017). Then, in light of this data, through a critical review of the literature (Scopus, Web of Science, Google Scholar), the main quantitative and qualitative problems related to water that Mediterranean Countries must face and that hinder the path toward fulfilling Agenda 2030 were identified. The study aims to present an overview of the main issues affecting water resources and water management in Mediterranean Countries, considering both qualitative and quantitative data with the goal of proposing practical tools for progression toward Agenda 2030. In particular, the study links the political, natural, and structural backgrounds of the Countries analyzed to their water-related situations, trying to identify which are the main challenges that prevent an optimal level of water availability, in terms of quantity and quality.

2. Water Resources in the Mediterranean Area

The Mediterranean is a water catchment area that covers over 5 million km². In 2018, just over 0.43% of the territory was covered by freshwater bodies, although unevenly distributed, with water bodies ranging from 0.86% in European Countries, 1.27% in the Countries of Asia, and 0.14% in the Countries of North Africa [11]. It is an environment severely affected by global warming, and as well as the Arctic; it is the most vulnerable environment to climate change globally. In fact, since 1982, temperatures have already increased by 1.5 °C, in sharp contrast to the global average of 1.1 °C [11]. The temperature increase could reach 2.2 °C in 2040, 3.8 °C in 2100, and a progressive reduction in reported changes (−10% in European Countries and −30% in the MENA region). At the same time, extreme rain, heat waves, and droughts could become 10–20% more intense and frequent, thus threatening the water supply of millions of people [12,13].

Indeed, the population of the 24 Mediterranean Countries today hosts more than 500 million people, with different growths and different trends: in the decade 2008–2018, the Mediterranean population increased by 11%, with rates of over 2% in Western Europe, almost 18% in the Middle East, 20% in North Africa, and 3% in Eastern Europe. The population currently living in urban areas is 70% and has increased by 38% since 1990 [14]. The water requirement of the Mediterranean area, estimated at between 500 and 1000 m³ per capita per year, has increased, due to the triple pressures given by the increase in population, urbanization, and irrigated agriculture. Parallel to the excessive exploitation of renewable water resources, all anthropogenic activities modify water regimes, degrading their quality [15,16].

The risk of damaging water resources is, therefore, among the highest in the world. The current situation of the Mediterranean population is classified as “poor in water” with less than 1000 m³ per year per capita (Figure 1A), and as United Nations estimates, this will affect about 250 million people by 2040 [17]. In the Mediterranean area, European Countries have greater water availability, although the per capita levels are not too high, while the MENA Countries are those where water is scarce. Indeed, freshwater is often lacking in Countries of the arid zone, where 320 million people live, penalized by chronic water shortages, partly related to the climate and the conformation of territories, but largely due to the mismanagement of water resources (Figure 1B).

Furthermore, it is crucial to consider that there may be different restrictions on the use of these water resources related to pollution or geopolitical disputes, for those Countries with access to numerous water resources. This combination of factors continuously exposes these regions to the risk of severe water deficit. Consequently, climate change, severe urbanization, and the extent of anthropogenic activities will affect the availability, quality, and quantity of water for essential human needs, thus threatening effective human rights to clean drinking water and sanitation, potentially for billions of people [18]. Water use in the

Mediterranean area for the different sectors varies considerably, according to the Country considered and the leading economic sector. Figure 2 shows a graph of the percentage consumption of water used in the three main sectors: agriculture, industry, and municipal. It can be highlighted that, on average, the sector that requires the most effective use of water is the agricultural sector (65%), followed by the industrial sector (23%), and then “domestic uses” (13%) [19]. The agricultural water use of rivers, lakes, and groundwater is the usage that has the highest impact on overall water consumption [20–22].

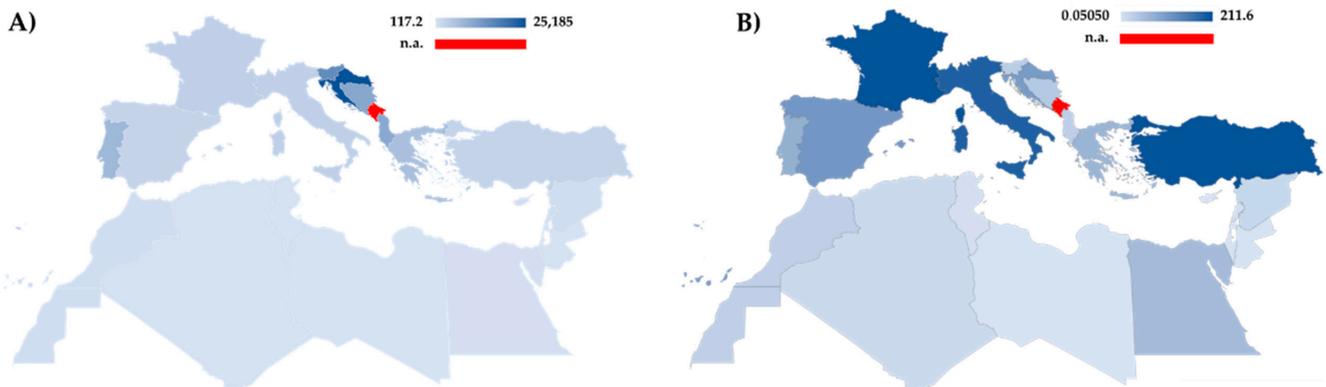


Figure 1. Total renewable water resources per capita (A) (m^3 /inhabitants/year) and total renewable water resources (B) (billion cubic meters) in Mediterranean Countries, 2017 [17].

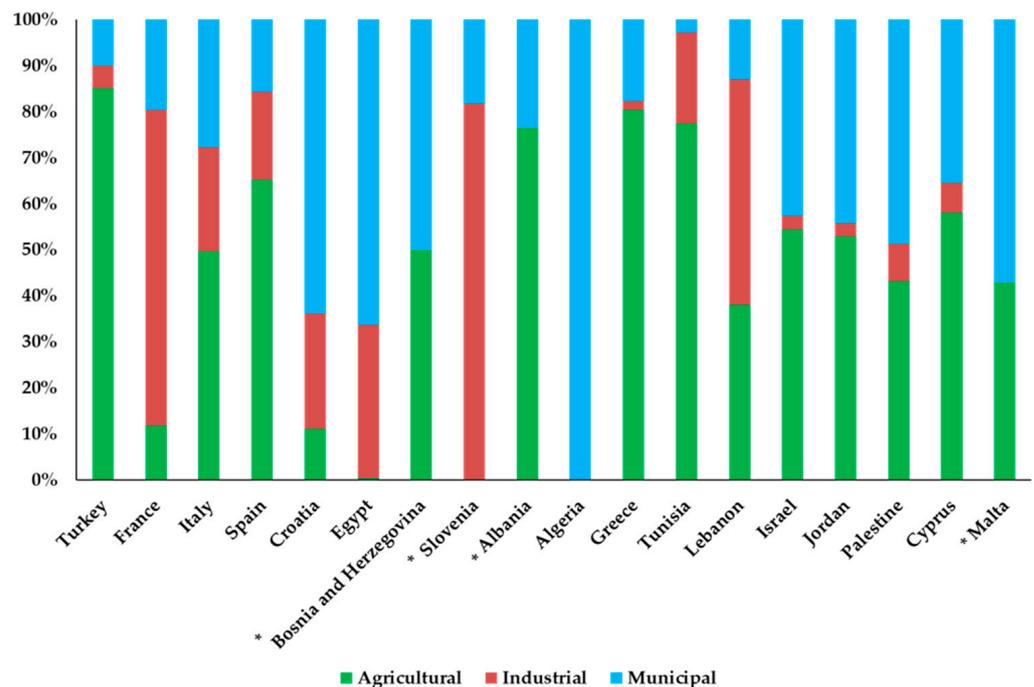


Figure 2. Water use percentages per year for main sectors, 2017 [17]. * Incomplete data.

In recent years, sudden climate changes have led to severe water scarcity and the aggravation of water stress, measured as total annual water withdrawals expressed as a percentage of the total annual available blue water [23]. Water stress has a negative influence on populations, ecosystems, and agriculture [24]. According to the World Resource Institute (WRI), the Mediterranean area characterized by MENA Countries has the highest water stress globally. Israel, Lebanon, Jordan, and Libya suffer from severe water stress (Figure 3) [25]. In these Countries, the situation is linked to the pedoclimatic conditions of the regions and how water resources are managed. Since water is the fundamental engine of economic development, water stress poses a serious threat to environmental

sustainability and the life and livelihood of human beings. Over time, there could be negative repercussions on the economic and political environments of Industrialized Countries (ICs)—or those not yet suffering from water scarcity—leading to a global water crisis. This could have catastrophic impacts on developing Countries (DCs) in the Mediterranean area because they are already subject to extreme events, such as droughts [26].

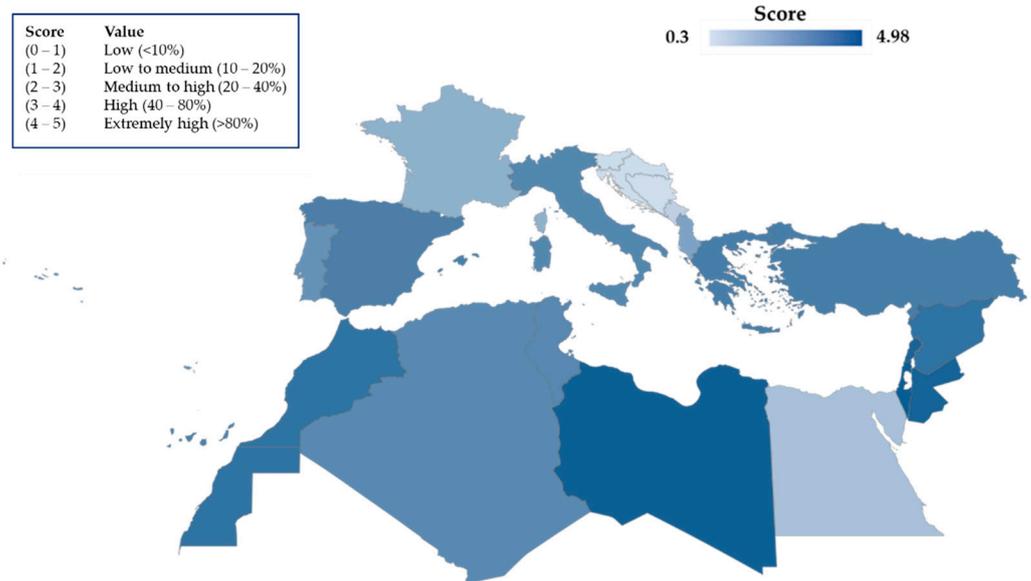


Figure 3. Water stress in Mediterranean Countries, 2020 [25]. (For Palestine and Malta, there are no literature data).

3. Materials and Methods

This research starts with an evaluation of the progress of Mediterranean Countries regarding Goal 6, “clean water and sanitation”. The databases used were “Aquastat” [17], “The SDG 6 data portal” [27], and “The global JMP database” [28].

Determining the progress rates of the different Countries concerning SDG 6 is made difficult due to the lack of data. This is also confirmed by the UN, which in 2018 found that less than 50% of Countries have comparable reference estimates for most of the global indicators of SDG 6. In fact, within the databases consulted, the latest data refer to the year 2017, only one year after the introduction of the SDGs, and for this reason, 2017 was taken as the reference year.

For each Mediterranean Country, all the indicators relating to Goal 6, for which there were available data, were considered, i.e., numbers 6.1.1, 6.2.1, 6.3.1, 6.4.1, 6.4.2, 6.5.1, 6.5.2, 6.6.1 (Table 1).

In general, the indicators used to carry out the study consider health and economic aspects, water structures, and geographical characteristics associated with water, which is essential information for this study. Each indicator was then interpreted to determine the state of the various Countries regarding the achievement of Goal 6. For some indicators, enough national data is not available to make an overall estimate. Information regarding good ambient water quality, water and sanitation, official development assistance programs, and stakeholders’ participation were not suitable for the study purpose, thus indicators 6.3.2, 6.a.1 and 6.b.1 were not taken into analysis.

Therefore, for a correct understanding of the current dynamics and of the factors that can hinder the performance of the various Countries, through a critical review of the literature, the main problems they face and that hinder good qualitative and quantitative water supply have been researched for each Country, toward achieving Goal 6. The Scopus, Web of Science, and Google Scholar databases were used for the literature review.

Table 1. Goal 6 and its targets. Main indicators considered for the Mediterranean area [20].

Target	Objects
6.1	By 2030, achieve universal and equitable access to safe and affordable drinking water for all
6.1.1	Proportion of population using safely managed drinking water services (%)
6.2	By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations
6.2.1a	Proportion of population practicing open defecation, by urban/rural (%)
6.2.1b	Proportion of population using (a) safely managed sanitation services and (b) a hand-washing facility with soap and water (%)
6.3	By 2030, improve water quality by reducing pollution, eliminating dumping, and minimizing the release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally
6.3.1	Proportion of safely treated domestic wastewater flows (%)
6.4	By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity
6.4.1	Water Use Efficiency (USD per cubic meter)
6.4.2	Level of water stress: freshwater withdrawal as a proportion of available freshwater resources (%)
6.5	By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate
6.5.1	Degree of integrated water resources management implementation (%)
6.5.2	Proportion of transboundary basins (river, lake basins, aquifers) with an operational arrangement for water cooperation (%)
6.6	By 2020, protect and restore water-related ecosystems (mountains, forests, wetlands, rivers, aquifers, lakes)
6.6.1a	Water body extent (permanent) (square kilometers)
6.6.1b	Water body extent (permanent) (% of Mediterranean land)

In addition, the search was carried out using the keywords “Water”, “Water resources”, “SDGs”, “Water availability”, “Water safety”, “Water pollution”, “SDGs”, and “SDGs implementation”, associated with the name of each Country of the Mediterranean basin.

The desired result is to propose possible opportunities and actions to progress toward Agenda 2030.

4. Results

Firstly, in order to evaluate the normal distribution of the data, the Shapiro–Wilk test was conducted on the data concerning the indicators of performance for the different Countries of the Mediterranean area (Table 2). The analysis showed that the data do not follow a normal distribution ($p < 0.05$). Therefore, in order to find significant differences between the performances of the different Countries in relation to the indicators of sustainable water management (SDG 6), the chi-square test was conducted and a $p < 0.01$ was considered significant. All statistical analyses were conducted using the Past4 Software (Oslo, Norway).

Then, according to the estimates developed by “the SDG 6 data portal”, it was possible to highlight the current state of SDG 6 in Mediterranean Countries, making it possible to identify the extent of the challenges faced and highlight the strengths and weaknesses of each Country for the indicators (Table 2).

Table 2. Mediterranean Countries' performance: main indicators [12,20].

	6.1	6.2		6.3	6.4		6.5		6.6	
	Drinking Water	Hygiene		Water Quality	Efficiency	Water Stress	IWRM		Ecosystems	
	6.1.1	6.2.1a	6.2.1b	6.3.1	6.4.1	6.4.2	6.5.1	6.5.2	6.6.1a	6.6.1b
EUROPE										
Albania	70%	n.a.	39.9%	67%	\$6.27	7%	43%	76%	523	1.8%
Bosnia and Herzegovina	89%	n.a.	22%	23%	n.a.	n.a.	61%	93%	203	0.4% ⁱ
Croatia	90%	n.a.	58%	59%	\$58.71	2%	90%	n.a.	641	1.1% ⁱ
Cyprus	100%	n.a.	75%	37%	\$59.17	30%	91%	n.a.	12	0.1% ⁱ
France	98%	n.a.	88%	n.a.	\$83.53 ^f	23%	100% ^g	53% ^h	3744	0.6% ⁱ
Greece	100% ^b	n.a.	90% ^c	n.a.	\$15.15	23%	83% ^g	58%	2928	2.2% ⁱ
Italy	95%	n.a.	96%	n.a.	\$48.85	30%	55%	100%	3652	1.2% ⁱ
Malta	100%	n.a.	93%	100%	\$161.23	85%	75%	n.a.	2	0.6% ⁱ
Montenegro	94%	0.05%	n.a.	n.a.	\$10.85 ^f	n.a.	34%	79%	262	1.9%
Slovenia	98%	n.a.	83%	63%	\$42.63	6%	58%	100%	44	0.2% ⁱ
Spain	98% ^b	n.a.	97% ^c	90% ^d	\$36.21	43%	82% ^g	100%	3156	0.6% ⁱ
MENA										
Middle East										
Israel	10%	n.a.	94%	91%	\$125.67	103%	85%	n.a.	458	2.1%
Jordan	94%	0.19%	81%	83%	\$34.98	100%	63%	21% ^h	445	0.5% ⁱ
Lebanon	48%	n.a.	22%	13%	\$25.64	58%	32%	n.a.	17	0.2% ⁱ
Palestine	n.a.	0.16%	61%	69%	\$31.18	41%	n.a.	n.a.	n.a.	n.a.
Syrian A.R.	n.a.	0.67%	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	981	0.5% ⁱ
Turkey	0%	0.31%	65%	35%	\$13.58	45%	70%	n.a.	11,962	1.5% ⁱ
North Africa										
Algeria	n.a.	0.8%	17.6% ^c	18%	\$14.36 ^f	138%	n.a.	n.a.	386	0.02% ⁱ
Egypt	n.a.	n.a.	61%	58% ^d	\$4.37	118%	n.a.	n.a.	6519	0.65% ⁱ
Libya	n.a.	n.a.	26% ^c	15% ^d	\$3.79	817%	47%	n.a.	60	0.003% ⁱ
Morocco	70%	7.2% ^a	39%	43%	\$8.42 ^f	50%	64%	n.a.	589	0.13% ⁱ
Tunisia	93%	n.a.	78%	71%	\$7.73 ^f	121%	n.a.	80%	297	0.18% ⁱ

^{a-d, f-i} Different letters express that there is no significant difference among the value of column and row.

The indicators analysis shows that more than 30 million people in the Mediterranean region still do not have access to safely managed drinking water (target 6.1.1), and 160 million people do not use sanitation and essential services to wash their hands at home (target 6.2.1). From available data from 17 Countries, in just four Countries (Jordan, Israel, Malta, and Spain) more than 80% of all domestic wastewater streams have been treated safely, and this percentage reaches more than 90% in just three Countries (Israel, Malta, and Spain) (target 6.3.1). These values are particularly worrying because the quality level of the water returned to the environment influences the possibility of obtaining reusable water safely. It follows that a large part of the population of the entire

Mediterranean area could potentially be drinking contaminated water. Furthermore, it is necessary to highlight the critical situation relating to water stress (target 6.4.2). This phenomenon affects all Mediterranean Countries, but it is very evident in the MENA region, which, in 2017, recorded the highest levels of water stress, with alarming values in North Africa, especially Libya, Algeria, Tunisia, and Egypt [12]. Regarding integrated water resources management (IWRM) (target 6.5.1, 6.5.2), in 2018, almost all Countries showed low/medium-low levels of implementation, and with this pace, it will not be easy to reach the implementation goal by 2030. Water scarcity derives from the absolute lack of water resources and the lack of development of the water sector. Indeed, water scarcity can be linked to complex pedoclimatic conditions in some Countries, especially in the arid and semi-arid zone, where the frequency of chronic drought hinders the annual renewal of water resources.

On the other hand, water insecurity derives from ineffectively managing water resources, thus generating problems that hinder water supply. These data show that most states, particularly the DCs of the MENA region, are still far from achieving satisfactory results and, unless current rates of progress increase substantially, Goal 6 will not be met by 2030. However, as the indicators are derived from aggregated data, they do not provide comprehensive information on the underlying causes of each situation. The literature review shows that the main challenges affecting the Europe and MENA macro-areas in the Mediterranean region are water quantity and quality problems. As shown in Figure 4, the main problems are chemical and biological water pollution, aquifers salinization, lack or inadequacy of infrastructure, and poor management of transboundary waters.

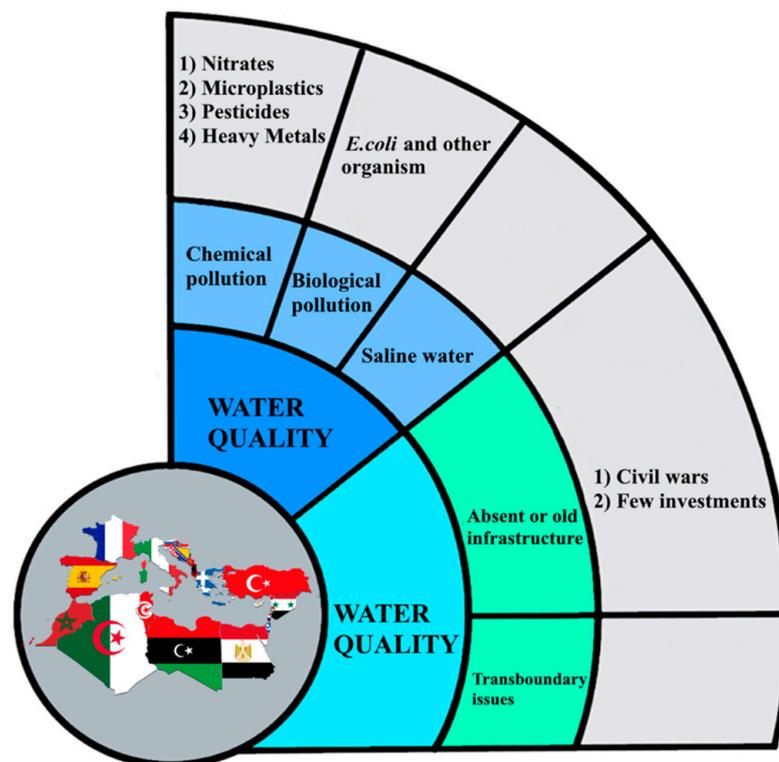


Figure 4. Major water-related problems in Mediterranean Countries.

4.1. Major Water Quality-Related Problems in Mediterranean Countries

(i) Chemical and Biological Water Pollution

Pollution caused by anthropogenic activities has been found in most of the studies and it is a problem that affects almost all the Countries of the Mediterranean area. The type of pollution that most Countries face is both of chemical and biological origin [29]. Regarding chemical water pollution, the study of the literature revealed that the major pol-

lution problems are linked to the presence of nitrates in surface and groundwaters [30,31]. Nitrate pollution does not concern only Mediterranean Countries but is a global problem and is undoubtedly of considerable importance for maintaining water resources. Nitrogen may be present in soil and water mains in four forms (gaseous nitrogen, organic nitrogen, ammonium ion, and nitrates), and it can be introduced into the environment by inorganic fertilizers, human and animal waste, etc. The concentrations of nitrates in Mediterranean waters oscillate between 4 to 496 mg L⁻¹ in MENA Countries and between 3.23 to 50.1 mg L⁻¹ in European Countries [31–33]. Balestrini et al. (2021) have shown that the increase in nitrate pollution in Mediterranean Countries is often related to the increase in livestock and intensive agriculture, given that the nitrates come from synthetic fertilizers [32]. However, nitrates in aquatic systems also come from other sources. In this regard, another critical point relating to nitrate pollution, highlighted by the literature, is the lack of or poor treatment of urban and non-urban wastewater, which involves the introduction of these pollutants into surface watercourses [33,34].

The excessive presence of nitrates in aquatic systems can cause eutrophication, resulting in the loss of aquatic organisms and a reduction in biodiversity [35]. Nitrate contamination affects water quality, reduces its availability, and aggravates water supply problems, especially in the driest Countries of the Mediterranean area, including Lebanon, Libya, Tunisia [36,37], Morocco [38–40], Algeria [41–43], and Egypt [44], which already face water scarcity problems. Several actions have been taken to reduce the negative impacts of nitrate pollution. For example, in Europe, two directives have been issued. Firstly, Directive 91/676/EEC [45], according to which each state should define the zones vulnerable to nitrates and then apply appropriate agricultural practices to reduce the impact of fertilizers on surface and groundwaters. Moreover, Directive 2000/60/EC establishes that the levels of nitrates in all surface waters within the European Union must not exceed 50 mg L⁻¹ NO₃⁻ [46]. However, despite these directives, nitrates remain a significant pollutant in European freshwater bodies. In the MENA area, the situation is much worse, and in many Countries, there is no accurate regulation. If standards and guidelines are specified, they are disregarded due to the technical and economic impossibility of carrying out works suitable for their compliance, including adequate wastewater treatment plants.

Another relevant problem is linked to heavy metals pollution, such as Arsenic (As), Plomb (Pb), Nickel (Ni), Copper (Cu), etc. These heavy metals are found at different concentrations (0.06–1822.4 µg L⁻¹) in Mediterranean Countries' freshwater resources [33,47,48]. Heavy metals contamination is due to the toxicity of metals and their harmful effects on aquatic organisms [47]. Human exposure to heavy metals occurs through the ingestion of contaminated food. In fact, some crops, especially cereal (wheat and rice) are able to store significant amounts of heavy metals, which, once ingested, are bioaccumulated, especially in the liver and kidneys, with systemic toxic effects. In particular, Hexavalent Chromium (Cr) and As are highly toxic even in low amounts, being carcinogenic and affecting the physical-motor functions of human bodies. The presence of Cr can derive from dyes, implemented during tanning processes, or from commercial sludge used in agriculture as fertilizer for fields. Concerning As, prolonged exposure can result in skin damage and cancer, and it is mainly industrially used as an alloying agent and in the glass and textile industries. Another material whose presence in water creates great concerns is Uranium (U), which can derive from leaching from natural deposits, mill tailings, and phosphate fertilizers.

From the analysis of the literature, it has been highlighted that heavy metals pollution in the Mediterranean basin is more evident in the DCs (Algeria, Albania, Lebanon, Libya, etc.) of this area, due to rapid economic growth and poor waste disposal infrastructure [47–49].

The anthropic activity growth linked to a demographic increase in Mediterranean Countries has had a significant impact on the agriculture sector. Therefore, in recent decades, it has been necessary to apply a wide variety of pesticides in agricultural and non-agricultural practices, such as chlordecone, methomyl, α-endosulfan, methamidophos

ethion, HCB, DDT, etc. [50]. This intensification has been evident mainly in the DCs of the Mediterranean basin, causing an increase in water resource contamination with these compounds and their degradation products. Due to the presence of pesticides, water pollution is a potential risk not only for human health but also for aquatic and terrestrial ecosystems. Studies in the literature have shown how the increase in pesticides pollution in surface water and groundwater is influenced not only by anthropic activities [51] but also by the pedoclimatic conditions of Mediterranean Countries and the sudden climatic changes of recent years [52].

In addition to these problems, other types of water pollutants have been highlighted. One of the most significant problems of recent years is attributable to plastic in water [53]. Recently, the microplastic pollution problem, found in concentrations reaching up to 7000 ng L⁻¹ in numerous freshwater basins, caused by an increase in plastic debris in surface water, has become significant in Mediterranean Countries [53,54]. Plastic particles entering the water cycle cause severe damage to aquatic ecosystems and human health. On the other hand, human activities are making a significant contribution to water pollution, as wet markets and slaughterhouses generate vast amounts of wastewater during the washing process. Open food markets selling poultry, fish, meat, fresh fruit, and vegetables are also associated with wastewater production. This wastewater is discharged directly into the sewage system without treatment. Consequently, wastewater is a quintessential source of water pollution due to the high concentrations of nutrients, which could cause eutrophication [55]. Another fundamental aspect to be evaluated to determine the quality of water is microbiological pollution. The identification of the presence of contaminating microorganisms (e.g., *E. coli*) or pathogenic microorganisms (e.g., *Giardia* spp., *Cryptosporidium* spp.) allows for limiting the spread of diseases potentially harmful to humans [56,57]. The presence of microbial water contamination is mainly linked to the spillage of civil and/or livestock sewage, incorrect water treatment, and the inability to disperse the microbial load of the receiving water body [58]. The Mediterranean MENA Countries, which also correspond to the DCs, still encounter significant problems related to the microbial pollution of water resources. The freshwater of DCs still have a high presence of *E. coli* (1.0-7800 CFU/100 mL) [58,59]. In this regard, Msilimba et al. (2013) [60] also highlight the problem of the proximity of wells to waste pits, latrines, stagnant water, and animal pens as a driver of the fecal contamination of drinking water in the MENA region. In addition to the contamination of the point of origin, water quality may deteriorate during use, especially during transportation and domestic storage. However, despite having state-of-the-art water infrastructures, the ICs of the Mediterranean basin are not exempt from microbiological water pollution problems. In these Countries, the leading cause is the illegal spillage of untreated wastewater into watercourses. Ligda et al. (2020) [61] have shown the presence of *Giardia* spp. (11.2 CFU/L) and *Cryptosporium* spp. (0.9 CFU/L) in wastewater discharge points in Greece. The problem of the chemical and biological pollution of water in Mediterranean Countries determines a slowdown in the achievement of the Sustainable Development Goals (SDGs).

Poor water management causes problems that mainly affect the safety of drinking water (target 6.1), water quality allowing for the survival of aquatic and non-aquatic ecosystems (target 6.3), and the efficiency of water use for anthropogenic activities (target 6.4). Failure to achieve these three fundamental aspects of SDG 6 limits the ability of the industrialized and developing Countries of the Mediterranean area to achieve other objectives of Agenda 2030. Poor management of water resources negatively affects the possibility of economic growth of the poorest populations (SDG 1) and consequently the possibility of reducing hunger (SDG 2) in the DCs of this area. Failure to achieve these two goals limits the possibility of ensuring a good state of health and well-being for the entire population (SDG 3) and reducing gender inequalities (SDG 5). Furthermore, the failure to control water pollution problems has a significant impact on the possibility of preserving aquatic ecosystems (SDG 14) and terrestrial ecosystems (SDG 15), significantly affecting the quality of human life on Earth.

(ii) Water salinization

A particularly significant problem within Mediterranean Countries is related to the salinization of aquifers. The assessment of water salinity is measured mainly by taking into consideration the concentration of dissolved NaCl. Typically, water salinity is low when the NaCl concentration is less than 0.5 mg L^{-1} . In addition, the pH (7.21–7.96) and the electrical conductivity ($5\text{--}10 \text{ }\mu\text{S/cm}$) are taken into consideration for the evaluation of water salinity [62]. The results from the literature have highlighted that freshwater salinity is a widely reported problem, especially in the arid/semi-arid areas of DCs, where about 381 million people live, even if in recent years this phenomenon has also spread to other Mediterranean Countries (Spain, France, and Italy) with less adverse climatic conditions [62–64].

Salinity studies in Tunisia, Algeria, Libya, and Morocco indicate that most underground wells are strongly brackish [42,65–67]. High salinity ($320\text{--}3862 \text{ mg L}^{-1}$) in groundwater has also been reported in almost all wells in Egypt [38,68]. Given the region's level of aridity in MENA, water shortages are common throughout these macro-area Countries. It follows that agriculture is allowed only in coastal areas and is heavily dependent on groundwater [65]. Practicing agriculture in coastal areas, however, excessive pumping too often causes saltwater intrusion into the aquifers, making the groundwater unsuitable for agriculture and drinking purposes [69,70]. High levels of salinity can affect water potability, induce serious health problems, and affect crop production [63,71,72]. Agricultural irrigation with increasingly saline groundwater causes high salinization levels in the local soil, leading to infertility and desertification [73]. All of this seriously affects food security, and it is estimated that within the arid/semi-arid areas, the losses of agricultural production linked to salinization are between 18% and 43% in addition to the fact that a deficit of freshwater, such as that in Egypt and Libya, could induce a significant increase in food prices, potentially resulting in increased socio-economic instability [74]. Currently, in some Countries, including Israel, the problem of water salinization is partially solved through desalination technologies. However, due to high procurement costs and adverse environmental effects, large-scale desalination is still underdeveloped and not sustainable for many DCs [75]. The problem of salinization makes SDG 6 impossible to achieve, also preventing the achievement of target 6.1 "safe water", target 6.3 "better water quality", and target 6.5 "integrated water resources management". The failure to achieve Goal 6 limits the possibility of achieving most of the Sustainable Development Goals. For example, the salinization of water and soil hinders the achievement of SDG 2 (zero hunger), the reduction in climate change (SDG 13), habitat conservation (SDG 14), and "life on land" (SDG 15).

4.2. Major Water Quantity-Related Problems in Mediterranean Countries

(i) Improper or absent infrastructures

Another problem widely highlighted concerns the inadequacy of infrastructures, including networks of pipelines, pumps, and treatment plants. This is a common obstacle for the entire Mediterranean area, but what differs from Country to Country are the reasons behind the water infrastructure inadequacy. Among the European Countries, the criticalities are mainly due to the age of the networks and implants. According to the European Commission, about seven million kilometers of pipes within the European Union have been in operation for more than 100 years. This is essentially due to low investments in water infrastructure. It is estimated that in Europe, an average of about 45 billion euros is invested per year, or only €93.5 per inhabitant [76]. Among the MENA Countries, such as Libya [65], Algeria [77], Turkey [78], Syria, Lebanon [79], Palestine, and Jordan [80], damage to water infrastructure was mainly caused by past or ongoing conflicts. These are fragile Countries, and unstable regimes characterized by inadequate state capabilities and repeated civil wars have destroyed and damaged most water infrastructures [65].

Targeting environmental infrastructure is an increasingly widespread form of warfare, particularly in MENA Countries, with long-term implications for state reconstruction,

livelihood support, and conflict resolution [65]. War involves limited access to social services (water, sanitation systems), leading to an increase in diarrheal diseases. Moreover, civil wars also disrupt the supplies of fuel needed to run water pumps and power plants, significantly limiting the performance and sustainability of agriculture. Other times, the impacts of war on the water crisis and water use are indirect. For example, following the Syrian crisis, Lebanon had to host many Syrian refugees, and, currently, with over 1.5 million refugees, it hosts the largest number of refugees per capita in the world. This resulted in a sudden increase in demand for water in refugee camps and settlements, creating water shortages for both refugees and host communities and significantly contributing to increased water stress [79]. Poor, broken, or obsolete infrastructures, in addition, cause the total absence of water supply, and also represent water losses or a waste of resources, in addition to the fact that broken or clogged wastewater pipes can cause the discharge of untreated wastewater into local watercourses. The data confirm the backwardness and inadequacy of water infrastructures: within the Mediterranean area, water losses are between 20% and 50%, and 55% of water is not treated by purification networks (Figure 5A). The water comes out of the taps in fits and starts, especially in the Balkan area and in some North African Countries (where the percentage of the population using safely managed sanitation services and hand-washing facilities with soap and water does not even reach 60%) (Figure 5B).

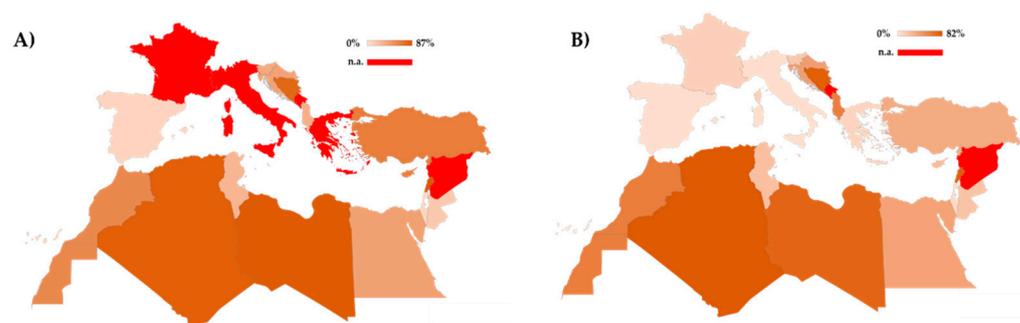


Figure 5. Percentage of domestic wastewater streams treated insecurely (A) and the percentage of the population that does not use safely managed sanitation facilities (B), 2017 [17].

To reverse this negative trend, cities will need to build adequate infrastructures in response to climatic and socio-economic challenges. Therefore, essential investments are needed to produce positive effects for the health of the territory and benefit employment rates. However, according to the UN Environment Programme (UNEP) (2013), the cost of renovating old urban infrastructures (in ICs) and building new ones (in DCs) is very high, around 22.6 trillion dollars, of which wastewater infrastructure is responsible for the largest share. These figures are almost unattainable for already impoverished Countries [81]. The lack of infrastructure will hurt water availability for humans as a driver of a level of purification services, sanitation, and hygiene (target 6.1, 6.2, 6.4). The lack of water facilities could lead to gaps in economic growth (SDG 8) and infrastructure (SDG 9), contributing to widespread hunger (SDG 2) and poverty (SDG 1).

(ii) Transboundary waters issues

Transboundary waters concern both surface water sources shared by several states and groundwater aquifers. In this regard, attention should not only be paid to the main path of a reservoir, but to the overall water system that feeds it, which in turn consists of different sources of varying extent, length, and nature. According to data from nine Countries (Albania, Bosnia and Herzegovina, France, Greece, Italy, Montenegro, Slovenia, Spain, and Tunisia), the average percentage of cross-border basins covered by an operating agreement was 50% in the period 2017–2018. Only three Countries (Italy, Slovenia, and Spain) have their cross-border basins covered by water agreements [12–20]. The worst situation is found in the MENA area. Due to the fragmented and heterogeneous institutions

and the feeling that territorial sovereignty prevails over cooperative management, the cross-border nature of the basins complicates the proper planning, development, and management of water resources [82–84]. This results in difficulty in allocating available water resources between Countries fairly and reasonably. This determines a phenomenon also known as “water grabbing”, a situation in which a power actor takes control or diverts water resources to their advantage, taking them away from local communities or entire nations, whose livelihood is based on those same resources and those same ecosystems that are plundered. As a result, conflicts and competitions over water quantity often arise, which further exacerbate the availability of water resources in Countries already tested by water scarcity, resulting in intermittent water supply [85–88]. In this regard, De Stefano et al. (2010) [89] have shown that the totality of existing conflicts directly concerning the control of water resources does not manifest itself in military actions, but political tensions and instability in relations between states. Cross-border basins represent the terrain of significant distribution inequalities and are managed by still-controversial agreements involving a significant number of Countries (Table 3). This is, for example, the case of the Nile, which flows through eight Countries and represents an important source of wealth for their populations [89]. As Egypt is the Country furthest downstream from the river, it is highly vulnerable to upstream activities [68,89], and the construction of hydraulic infrastructures—such as the large Ethiopian dam—on shared water resources can increase the possibility of conflicts [90,91]. Other important conflicts in Mediterranean Countries concern the waters of the Jordan River, over which Israel, Jordan, Syria, Lebanon are conflicted, despite the fact that Israel is the main “consumer” of its waters. After all, Israel’s primary water resources are found in the territories occupied during the wars of 1948 and 1967 (Golan Heights, the West Bank, and the Gaza Strip). The disputes between Countries are confirmed in the “Dependency Ratio”, which expresses the percentage of total renewable water resources from upstream Countries. Some Countries such as Egypt, Portugal, and Croatia are heavily dependent on water from neighboring Countries, with a Dependency Ratio above 90% (Figure 6) [17].

Table 3. Main disputes for river basin management in the Mediterranean basin.

Rivers	Countries	Focus	Ref.
Euphrates	Turkey, Syria	Water resources of the Euphrates River basin have been severely depleted by the numerous dams built in Turkey, which have reduced, by 1/3, the water flow to the two downstream Countries, (Syria, Iraq) which risk serious drought. Turkey can exploit its dominance in terms of economic strength, political influence, and military capability, while in the two Countries downstream, these aspects are limited due to their internal political fragmentation and weaker military status	[86–89,92]
Jordan	Israel, Jordan, Syria	The Jordan River is disputed between Israel, Jordan, Syria, and Lebanon, but Israel is the main “consumer” of its waters. After all, Israel’s main water resources are found in the territories occupied during the wars of 1948 and 1967 (Golan Heights, the West Bank, and the Gaza Strip).	[93–95]
Nile	Egypt	The Nile originates in Equatorial Africa and crosses 7 states before arriving in Egypt. The amount of water that this latter nation can use therefore depends on the upstream Countries. Though the conflict between Egypt and Sudan ended with a treaty in 1959, with Ethiopia the situation is still problematic.	[96–99]

In addition to the scarcity of water and water insecurity, there is an economic and social component on the part of Countries—especially DCs—which seek to exploit water as a source of income and a tool for the regional affirmation of its neighbors.

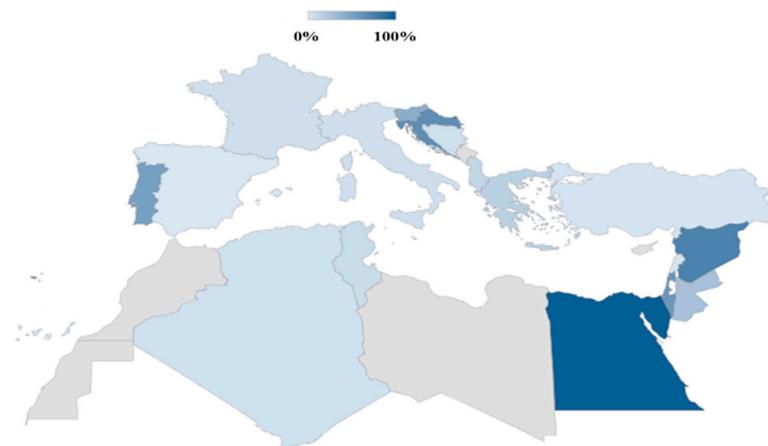


Figure 6. Dependency ratio by Country, 2017 [17].

Disputes between Countries are negatively correlated with the possibility of ensuring drinking water supply for all (target 6.1, 6.2, 6.4), contrasting the inclusion of local communities in sanitation facilities (6.b).

Furthermore, in a continuous war situation, gender equality (SDG 5) and sustainable cities and communities (SDG 11) also seem difficult to achieve, considering that the life quality of a “war-affected population” reaches critical levels in terms of health, well-being (SDG 3), and malnutrition (SDG 2).

5. Discussion

Within the Mediterranean area, there are still severe inequalities in access to water and sanitation, and to achieve the objectives of the 2030 Agenda, the Countries that are part of this area still face major challenges, as summed up in Table 4. It follows that all Countries will have to improve their performance significantly, and within this research, some opportunities are identified that Countries can and must seize to increase, preserve, and safeguard access to water, to promote more equitable and sustainable distribution (Table 5).

5.1. Water Quality-Related Problems: From Evidence to Possible Solutions

(i) Denitrification processes, bioremediation techniques, disinfection technologies

Water pollution of both chemical and biological origin is the greatest threat to the Mediterranean Countries, partly attributable to the upsurge in agricultural and industrial activities and anthropic action in these areas and sudden climate changes [100,101]. Regarding chemical pollution, the presence of nitrates in surface and groundwater represents a constant obstacle that threatens the possibility of having access to safe, drinkable water and improved water quality (SDG 6.1, 6.2, 6.3) [30,31]. Nitrogen-containing compounds are an example of contaminants that may cause serious damage to the environment and water quality and pose potential risks to human and animal health when released into the environment. In recent decades, the need to reduce the accumulation of nitrates in groundwater led to the development of technologies able to exploit the biological phase of the cycle of nitrogen, namely denitrification, to remove dissolved nitrate in water and transform it into molecular nitrogen, released into the atmosphere, through the process of denitrifying bacteria. This technique combines the effectiveness of removal and relatively low costs [102–104]. Otherwise, the contamination of groundwater and surface water by heavy metals, pesticides, and other chemical pollutants is one of the major problems facing the ICs of the Mediterranean basin (e.g., France, Italy, Spain, etc.) and the Middle East Countries. The need to rehabilitate these contaminated areas has led to the development of new technologies aimed at destroying polluting compounds.

Table 4. Main water challenges facing Mediterranean Countries.

Mediterranean Countries (MC)	QUALITY						QUANTITY					WRM	SDGs Linkage	
	Chemical Pollution				Biological Pollution		Saline Aquifer	Water Losses	Agricultural Withdrawn	Transboundary Disputes	Internal Conflicts			Lack of Infrastructures
	Nitrates	Heavy Metals	Pesticides	Other	<i>E. coli</i>	Other								
Albania		×		×						×			6.3, 6.4	
Algeria	×	×	×				×	×		×			6.1, 6.2, 6.3, 6.5, 6.a	
B. Herzegovina									×	×		×	6.5, 6.6, 6.a, 6.b	
Croatia				×									6.2, 6.3, 6.6	
Cyprus		×		×									6.3, 6.5	
Egypt	×	×				×	×			×			6.1, 6.3, 6.5, 6.6, 6.b	
France			×	×			×		×				6.3, 6.4, 6.5	
Greece	×	×				×							6.3, 6.4, 6.6	
Italy	×		×	×					×			×	6.3, 6.4, 6.5	
Jordan							×			×			6.1, 6.2, 6.b	
Lebanon	×	×	×	×	×		×				×		6.3, 6.4, 6.a	
Libya	×	×					×	×				×	6.1, 6.2, 6.3, 6.5	
Malta				×			×		×		×		6.1, 6.3, 6.4, 6.5	
Morocco	×						×					×	6.1, 6.3	
Palestine	×				×		×			×			6.1, 6.2, 6.3, 6.a	
Portugal	×	×	×	×			×	×					6.3, 6.4, 6.6	
Slovenia	×											×	6.1, 6.2, 6.3, 6.4, 6.b	
Spain	×		×			×	×		×				6.3, 6.4, 6.5, 6.a	
Syria				×				×		×		×	6.5, 6.6, 6.a, 6.b	
Tunisia	×						×	×					6.1, 6.2, 6.3, 6.b	
Turkey	×			×					×				6.3, 6.4, 6.6, 6.a	
Total MC	13	8	6	10	2	3	11	6	6	7	2	2	4	

“×” means that problem listed in the Table are present in that Country.

Table 5. Main challenges and opportunities in the Mediterranean area.

Challenges	SDG 6: Indicator Involved	SDGs Involved	Opportunities
Chemical (nitrates, plastics, heavy metals, pesticides) and biological (<i>Escherichia coli</i> and other microorganisms) pollution	6.1, 6.2, 6.3, 6.6	1, 2, 3, 8, 10, 11, 12, 13, 14, 15, 17	<ul style="list-style-type: none"> • Denitrification processes. • Bioremediation techniques (as the use of electrochemical membrane biofilm) for pesticides, antibiotics, PCBs, PAH, and heavy metals pollution. • Water disinfection technologies for biological pollution (ultrasound, microfiltration, ultraviolet irradiation, ozone, ultrafiltration).
Brackish and/or saline waters	6.1, 6.3, 6.a	1, 2, 3, 7, 8, 10, 12, 14, 15, 17	<ul style="list-style-type: none"> • Desalination plants powered by renewable sources (solar, wind, geothermal).
Non-properly or absent water infrastructure	6.4, 6.5, 6.a	1, 2, 3, 8, 9, 10, 12, 13, 14, 15, 16, 17	<ul style="list-style-type: none"> • Supply-side policies for building efficient water infrastructure. • Decentralization and modernization of irrigation. • Sustainable use of groundwater. • Increase in private investments.
Transboundary waters issues	6.4, 6.5, 6.b	1, 2, 3, 8, 10, 11, 13, 14, 15, 16, 17	<ul style="list-style-type: none"> • Involvement of many stakeholders. • Sharing and exchange of data and information. • Establish commissions made up of representatives from the governments of the Countries involved.

One of these techniques, bioremediation, uses the metabolic potential of microorganisms playing a pivotal role in biogeochemical cycles to decontaminate polluted environments. Bioremediation techniques have been successfully used to decontaminate sites affected by oil pollution, polychlorinated biphenyls (PCBs), trichloroethylene (TCE), perchloroethylene (PCE), trinitrotoluene (TNT), and BTEX (benzene, toluene, ethylene, and xylene) [105]. Li et al. (2021) [106] also demonstrate in their study the possibility to use an electrochemical membrane biofilm reactor as a bioremediation technology to remove antibiotics (e.g., sulfonamides) from wastewater. This emerging biological technology, based on gas transfer membranes as biofilm conveyors to degrade pollutants, offers the advantage of robust performance and no chemical requirements at low costs [107]. Additionally, regarded as biological water pollutants, the main threat to groundwater, as the

almost singular drinking water source in DCs, is the potential presence of fecal bacteria (e.g., *E. coli*) resulting from a variety of pollution sources and pathways, including septic tanks, landfills, and crop irrigation with insufficiently treated or untreated wastewater. Numerous studies have been performed on the risks attributed to irrigation water quality as a source of pathogenic micro-organisms (e.g., *E. coli*) in food [108–111]. Overall, the need to ensure safe irrigation water to satisfy food safety and human health requirements is justified and will be made possible with effective water disinfection technologies. A recent prioritization of technologies to disinfect bacterial pathogens in irrigation water classified ultrasound, microfiltration, ultraviolet irradiation, ozone, and ultrafiltration respectively as the most effective disinfection technologies to treat surface water intended for food consumption [112]. This might represent an opportunity to improve water quality (target 6.3), thus guaranteeing equal access to safe drinking water (target 6.1, 6.2) and food products (SDG 2).

(ii) Desalination of renewable sources

Water shortages are becoming an increasingly frequent problem for Mediterranean Countries. One way to alleviate this situation could be by using unconventional water resources, such as wastewater and seawater. The desalination process separates seawater from its saline component by removing the dissolved solids, such as salt, minerals, chemical compounds, and organic matter [113]. Currently, various technologies are available for saltwater treatment, but they have some disadvantages. The two technologies widely used for desalination are “thermal process” and “membrane process” [114]. In most cases, however, both techniques require extremely high thermal or mechanical energy [115], because both the thermal and membrane processes are carried out by burning conventional energy sources, such as oil and coal, with the consequence that they exhale high levels of atmospheric emissions, resulting in a greater carbon footprint and heavily polluting the air [116]. Furthermore, the use of fossil fuels determines a very high total cost per unit of desalinated water, resulting in current technologies being expensive for the generation of a small amount of freshwater [117]. Finally, they could present problems related to the excessive development of bacteria on the membranes, which would cause taste and odor problems, mechanical problems caused by high pressure, and very high manufacturing costs [114]. Therefore, it will be necessary to use more sustainable solutions for water desalination. The use of renewable energy could be an effective way to manage desalination plants. The primary sources of renewable energy used in these plants are solar energy, wind energy, and geothermal energy. Their coupling with desalination systems is very promising for a fair compromise between water supply and sustainability within Countries suffering from water scarcity. Solar-powered desalination plants could be reasonable especially in arid/semi-arid areas, where solar energy is abundantly accessible and could be converted to high temperatures, which could be used for steam generation or to drive the plant through a photovoltaic cell that would exploit solar radiation. Wind energy-based desalination plants could also represent a promising system, especially in windier Mediterranean locations, although these plants require a wind energy converter for smoother working conditions [118].

Another renewable source that could be used, alongside wind and solar energy, is geothermal energy. Geothermal energy is independent of weather conditions and requires lower operating costs. However, geothermal energy requires high-cost thermal power plants, in addition to the limited locations of geothermal activity [114]. Considering the high environmental impacts and costs of current desalination technologies, many Mediterranean Countries, especially DCs, are unable to bear the related costs. Therefore, one of the best approaches could be to use sustainable energy sources that do not incur supply costs from fossil fuels. Since each energy source is related to reasonable accessibility, and the meteorological and pedoclimatic conditions of a specific area, one of the future opportunities for Mediterranean Countries could be the choice of appropriate sustainable energy sources. According to Abdelkareem et al. (2018) and Shah et al. (2018) [118,119], globally, there are only 131 desalination plants powered by renewable sources, and this

number is deficient in proportion to the total water desalination capacity (1% of the total desalination capacity). Therefore, more investments will be needed into this type of technology, and the Countries of the MENA area, abundant in solar radiation, could exploit this gap to improve their water production capacities.

Other Countries, such as the windier ones (Spain, Portugal, Greece), could exploit wind energy, and by their greater wealth than DCs could bear the costs related to the development of energy storage technologies. Finally, Countries that already exploit the geothermal energy available to them, under a favorable position, could use it not only for space heating but also for the activation of desalination plants, therefore taking advantage of pre-existing investments. In this way, it is possible to improve the performance regarding the indicators of SDG 6 and have a ripple effect on the other goals, including Goals 1, 2, 3, 10, 12, 14, 15, and 17. Therefore, it will be necessary for Countries facing brackish water problems to adopt the most efficient desalination technologies, exploiting a potential problem (aridity, excessive temperatures, intense sun) and transforming it into a possible opportunity, with modifications and additions based on the unique requirements of each Country. However, these technologies will also have to be used in combination with water education and awareness campaigns. Appropriate measures will consequently have to reflect each Country's contexts and the specific needs of their societies.

However, government efforts alone may not be enough in most cases, and private investment will also be needed to address the water challenges associated with desalination technologies.

5.2. Water Quantity-Related Problems: Possible Solutions

(i) Water infrastructures and irrigation efficiency, increase in private investments

As stated above, in the Mediterranean, water is a scarce and fragile resource that is unevenly distributed among the Countries of this area, and it is expected to be worsened by climate change, leading to more irregular and scarce rainfall. This water scarcity condition in the Mediterranean basin will weigh heavily on the economic activities of the Countries of this area, especially in the agriculture sector. The MENA region's age-old water scarcity challenges are exacerbated by the growing water demands, inter-sectoral competition, and urbanization. Against this background, poor, broken, or obsolete infrastructures represent an obstacle that negatively influences water storage capacity, further causing water losses and limiting access to its use [120].

Although many Countries (e.g., Tunisia, Morocco, Lebanon, and Italy) have implemented supply-side policies by building water infrastructures such as dams and wells, the problem persists.

Several case studies show that dams can alter the composition and density of different pathogenic micro-organisms in freshwater, increasing the incidence of water-borne diseases, soil erosion, and eutrophication of water basins. Furthermore, water supply methods are not enough to meet the growing population [120–122].

High fuel costs, lack of specialist knowledge for repairs, and lack of spare parts are some reasons for the failure of water infrastructure projects [123,124]. To overcome these obstacles, future investments in the infrastructure and technologies applied to water networks will be crucial. The strong demand for investments in the water sector is motivated by two priority needs: complete the construction of new infrastructure and maintain existing ones. Currently, in the Mediterranean, 90% of public aid for the water sector comes from a small number of bilateral donors, including the US (\$2.7 billion), Japan (\$2.3 billion), Germany (\$2.3 billion), and France (\$0.9 billion) and it is concentrated on a few Countries only: Egypt, Turkey, Tunisia, Morocco, and the Palestinian territories [14].

Addressing water fragility challenges requires a move to a balanced long-term approach focused on sustainable, efficient, and equitable water resource management and service delivery. The possibility of establishing and adopting regulations that introduce measures and incentives for all Mediterranean Countries to save water and increase supply productivity will be fundamental. Future investments in the efficiency of water infras-

structure could be strategic both for economic and geopolitical purposes. Furthermore, good agricultural and forestry practices should be encouraged, improving the efficiency of irrigation using small-scale irrigation and renewable water sources because of urban and industrial wastewater recycling. Finally, the implementation of sustainable water resource management practices should occur during the restoration of infrastructure—for example, strengthening dams or rehabilitating canals [12,13]. Beyond these near-term objectives for water infrastructure, longer-term goals for water management are essential. These include the decentralization and modernization of irrigation, the sustainable use of groundwater, the maximization of crops through appropriate water pricing policies (e.g., payment by volume of water used by farmers), and women's inclusion in decisions regarding natural resources. All of this strongly encourages the achievement of multiple SDGs, including gender equality (Goal 5), decent work and economic growth (Goal 8), and ensuring sustainable city development (Goal 11).

(ii) Integrated Water Resources Management

From the literature analysis, it has emerged that most governments still manage water resources at the national level, focusing attention on the use of water within national territories and ignoring the large-scale impacts of local water uses. Globally, there are about 276 hydrographic basins shared between several Countries, which host about 40% of the world's population. In Southeast Europe, 90% of the area falls within shared basins, and three or more states share more than 50% of these basins. To achieve the SDGs, Mediterranean Countries will need to establish common objectives that reorient national policies toward more efficient water use, implementing good water management practices in all economic sectors. In this regard, to effectively address water issues across multiple states, it is widely indicated in the literature that the correct way is integrated water resource management (IWRM). This intersectoral policy approach reflects the interconnected nature of water. It promotes the development and coordinates the management of water, soil, and related resources to maximize economic and social well-being equitably, without compromising the sustainability of vital ecosystems and the environment.

Decentralized and participatory approaches could represent an opportunity to improve the integrated management of water resources at all levels (Goal 6.5), also promoting gender equality (SDG 5).

Furthermore, the adequate integrated management of water resources promotes stability and peacebuilding (SDG 17), representing an opportunity to empower communities and develop inclusive institutions for reliable water supply and recovery.

In the Mediterranean region over the years, very few attempts have been made to manage water resources in a coordinated way, and, especially outside the EU, they have been quite limited [125]. The progress has been slow, due to a low concern for integrated management and little stakeholder participation. Transboundary waters have always been managed by governments as an integral part of their international political negotiations, entirely focused on the allocation of water quantities to the riparian states according to "quotas", and therefore based on the sharing or distribution of water resources. The objective of IWRM is not about sharing the resource itself, but about sharing its benefits. Another reason for the slow progress in IWRM, in general, is the lack of experience in participatory planning and drafting of water management plans, especially when multi-participatory consultations between neighboring states are required. However, within the Mediterranean, three cases have been identified, in which it is possible to note appreciable progress or success. These cases are the aquifer system of the northwestern Sahara, the Sava River, and the Drin River. Regarding the aquifer system of the Northwestern Sahara, it is shared between Algeria, Tunisia, and Libya, and is the main source of water for about five million people. A scientific committee was set up to manage this resource, involving the Sahara and Sahel Observatory, which allowed numerous researchers and experts to communicate, collaborate, and act together, sharing scientific experiences and data [125].

The Sava is a sub-basin of the Danube, shared between Slovenia, Croatia, Bosnia and Herzegovina, Montenegro, and Serbia, serving a population of 8.5 million people,

across a total area of 97,713.2 km² [126]. After a period of instability, the states came together to manage the waters of the river, eventually coming to an agreement called the “Framework Agreement on the Sava River Basin (FASRB)” (2004), establishing an evaluation commission, the “International Sava River Basin Committee (ISRBC)” (2005), made up of government-appointed party representatives (two Country representatives per party) [127]. The tools chosen for its implementation are the creation of standard development plans and the facilitation of national and European legislation [125].

The Drin River traverses five coastal Countries (Albania, Macedonia, Greece, Montenegro, and Kosovo), and after a series of different management approaches, often conflicting, some actions have been implemented toward the integrated management of this water resource. Cooperation between the coastal Countries was launched between 2006 and 2011 to facilitate the coordinated management of the basin, which ended with the establishment of the “Drin Core Group (DCG)”, an informal structure that serves to simplify communication and cooperation between riparians as well as the coordination of dialogue implementation activities [125]. At the end of this process, what emerged was a memorandum (Drin Mou) to promote a standard action for the integrated management of water resources in the Drin basin and identify the main cross-border problems [125]. The three cases cited represent examples that could inspire other attempts within the Mediterranean and demonstrate how the involvement of multiple actors can help substantially. This could provide multiple benefits for the Countries concerned because community consultation and participation are key driving forces of cooperation and respect for the essentially local nature of water problems. Collaboration and cooperation between Countries, in fact, could represent a strong push to resolve decennial disputes. The strategy will have to be based on going beyond the unilateral interests of nations and acting in cooperation between states, considering not the sharing of water resources, but the sharing of benefits.

The fundamental criteria will have to put human development at the center of the debate, replacing national management with international cooperation, exchanging data and information. It will be strategic to pursue policies aimed at avoiding conflicts in water use through integration plans between the agricultural, drinking, industrial, and environmental sectors. Indeed, these approaches are particularly valuable in fragile and conflict-affected areas, because they focus on building peace, dialogue, and cooperation between the state and civil society to solve water-related problems.

6. Conclusions

The management of water resources is a topic of great importance in the Mediterranean region. MENA Countries face the most significant challenges, since they are already penalized by structural conditions due to their position in arid/semi-arid climatic zones. Within this research, we started with the current state of the various Mediterranean Countries, considering their progress toward Sustainable Development Goal 6, “clean water and sanitation”. Then, through a critical review of the literature, the main challenges for Mediterranean Countries and the factors that hinder their good performance were identified. Indeed, all Countries face problems related to anthropogenic pollution, but in each macro-area, these challenges mainly depend on the prevailing type of activity. In fact, European Countries face pollution mainly due to heavy metals and microplastics, linked to large industrial activity, while in MENA Countries, the prevalent pollution is attributable to nitrates, linked to agricultural activities, and which support the economies of DCs. The intensity of agricultural activities also causes, especially in MENA Countries, the intrusion of brackish water into the aquifers, resulting in unusable water for both drinking and agricultural uses. Furthermore, these problems could be aggravated by the harmful effects produced by COVID-19. Consequently, food insecurity will mainly affect the poorest Countries, and political tensions over the control and use of water between Countries and local, national, and international groups will also increase. This situation is particularly alarming in North Africa, where the percentage of the population that does not use safely managed drinking water services reaches 52%, leaving 102 million people exposed to

possible diseases related to a lack of adequate sanitation, including COVID-19. Another problem concerns inadequate water infrastructure, as well as determinants of water losses. Suppose, in European Countries, that water losses are mainly due to low investments in the water sector in the MENA region, in which case, water losses are caused by continuous conflicts, which destroy infrastructure, leaving Countries fragile and without technological or economic possibilities for rebuilding. Most governments still manage water resources at the national level, focusing on water use within local territories and ignoring the large-scale impacts of local water use. Therefore, strict national standards will be required to limit water use and protect water sources as a primary common asset for the long-term survival of populations, ecosystems, and biodiversity. New sectoral plans, private and public investments, control protocols to improve the efficiency of water supply networks, and the development of new treatment technologies (denitrification, bioremediation techniques, disinfection technologies, and desalination plants from renewable sources) will be required. In the future, international cooperation will be indispensable to help Countries oppressed by conflicts and eliminate the logic of water allocation by “quotas”, thus shifting the focus from sharing water resources to sharing their benefits across Countries. Finally, it could be worth implementing educational programs encouraging the correct and conscious use of water resources from an early age, to train the citizens of the next generation and help them understand the implications of everyone’s life on a shared planet.

Author Contributions: All authors have contributed equally to the conceptualization and to the writing of the article. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Data generated is publicly available and cited in accordance with the journal’s guidelines. All data used to support the results, as well as publicly archived data sets, analyzed or generated during the study were cited within the text. There are no ethical, legal or privacy issues, there are no limitations in the declaration on data availability.

Conflicts of Interest: The authors declare no conflict of interest.

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