sustainability

MDPI

Article

Groundwater Pollution Impact on Food Security

Abdul Munaf Mohamed Irfeey [1], Mohamed M. M. Najim [2,*], Bader Alhafi Alotaibi [3] and Abou Traore [4]

[1] Department of Biosystems Technology, Faculty of Technology, South Eastern University of Sri Lanka, University Park, Oluvil 32360, Sri Lanka
[2] Department of Zoology and Environmental Management, University of Kelaniya, Kelaniya 11600, Sri Lanka
[3] Department of Agricultural Extension and Rural Society, College of Food and Agriculture Sciences, King Saud University, Riyadh 11451, Saudi Arabia
[4] Department of Community Sustainability, College of Agriculture and Natural Resources, Michigan State University, 328 Natural Resources Building, East Lansing, MI 48824, USA
* Correspondence: mnajim@kln.ac.lk

Abstract: Global food security challenges have been burdened by a rapidly expanding population and its attendant food demands. Safer and higher-quality agriculture is one of the most essential solutions for addressing the growing problem. In agriculture that is safer, the quality of irrigation from a safer water source will boost food security. Groundwater is one of the most widely utilized water sources for agriculture. Safeguarding groundwater against contamination and preserving water resources is a rising global concern. Herein, previous literature studies were analyzed to determine the groundwater potential for food production of the various continents around the globe, as well as the various types of groundwater contamination, the sources of groundwater contamination, and the best methods for combating groundwater contamination in order to guarantee safe irrigation for agriculture and thus achieve food security. Consequently, the natural and anthropogenic activities that degrade the quality of the groundwater and transform it into contaminated water from harmful organisms, residues of organic and inorganic soluble and non-soluble salts of the groundwater from chemical, leachate from landfills, sewage systems, and biological contamination, are the major issues in safer agriculture, causing a number of problems in the growth of agricultural crops and leading to a negative impact on food production as well as on the health of the population. Proper identification of different sources of contamination and proper methods to prevent contamination from reaching groundwater, as well as governmental and institutional frameworks to combat contamination and treatment methods to treat contaminated groundwater, will contribute to the future achievement of food security by ensuring a safer irrigation method and agriculture.

Keywords: food production; groundwater treatment; increasing food demand; safer irrigation

check for updates

Citation: Irfeey, A.M.M.; Najim, M.M.M.; Alotaibi, B.A.; Traore, A. Groundwater Pollution Impact on Food Security. *Sustainability* **2023**, *15*, 4202. https://doi.org/10.3390/su15054202

Academic Editors: Marc A. Rosen and Grzegorz Zaguła

Received: 23 January 2023
Revised: 20 February 2023
Accepted: 23 February 2023
Published: 26 February 2023

1. Introduction

The global population is expanding at an unprecedented rate, forcing the implementation of sustainable and equitable food systems at the forefront of sustainable development. The challenge of widespread food insecurity is a significant issue especially for emerging and underdeveloped countries [1]. Globally, severe food insecurity affects around 1.7% of the population [2] and recent findings indicate that the global community is failing to make sufficient progress toward its goal of eliminating hunger, food insecurity, and all kinds of malnutrition [3]. By 2021, the number of hungry people in the globe had risen to 10.5% of the global population, a rise of 46 million people from the end of 2020 [4].

A state of food security defines that all individuals, at any time, have access to, and are able to afford, enough nutritious and safe food to suit their dietary requirements and food choices in order to lead physically and mentally active and healthy lives [5,6]. The four primary aspects of food security are the availability of healthy food, the capacity to get food both financially and physically, the efficiency with which food is used, and the sustainability of these factors [7–9]. In accordance with the widely recognized definition of food security, in contrast to the ability of an individual to obtain food to satisfy his or her hunger, the availability of safe food and its continued availability in the future are both ascribed equal weight. Thus, safer foods are not given a high priority when comparing food availability, and the notion of food security is flawed. In light of the escalating food security challenges and their global ramifications, it is also necessary to address food safety issues. Each phase of food production techniques, including pre and post-harvest, must be safe in order to ensure food quality and food security, beginning with land preparation and continuing until the food reaches consumers [10,11].

Despite the fact that an increasing number of various food production and farming practices have been identified as a solution for managing the food security issues, unsustainable and unsafe farming practices play a significant part in food safety challenges, which the agricultural sector has yet to address [12]. To conquer food insecurity and improve the quality of life in the globe, constantly seeking and implementing effective strategies is needed, with the majority of identified aspects including reducing the need to clear land for safe and healthy agriculture by narrowing the gap between what is now produced and what might be produced, using fertilizer more efficiently, enhancing irrigation and reducing food waste. Irrigation and water availability are major obstacles to expanding agricultural productivity and ensuring food security [13,14]. Irrigation for agriculture and efficient irrigation systems have assumed greater importance in increasing food production due to the fact that a large portion of the global fresh water resources is used in agriculture [3,15].

Thus, the majority of the influence on the quality of the food produced rests with the agricultural techniques used on the farmland; farmers are primarily concerned with the quality of the seeds or plant materials; they do not prioritize the safety of the food for consumers. In spite of the fact that many policymakers and stakeholders have begun to consider this issue, measures such as switching to evaluate the water quality characteristics of the water used for field irrigation, which is one of the most important parameters in food quality, need more attention [15]. The presence of both organic and inorganic substances in polluted water poses serious health risks, with the resulting food becoming more deadly as the contamination spreads. On both a quality and quantity basis, polluted groundwater may have detrimental effects on humans. As regards the quality, it disrupts the groundwater's natural state and renders it unfit for irrigation; when used, such water may have negative effects on agricultural cultivation and consumer health due to the spread of disease and bioaccumulation [16]. On the other hand, as a consequence of pollution, the quantity of safer groundwater sources will decrease, resulting in a water shortage for irrigation, which would inevitably lead to a decline in food output and the emergence of food insecurity. To ensure global food security, it is essential to comprehend groundwater and determine whether or not it is acceptable for irrigation, improving the safety of food production while simultaneously enhancing productivity.

Thus, the specific objectives of this study can be summarized as follows:

- Examining the various types and sources of groundwater potential of the globe for food production;
- Different types of contaminations in groundwater and their impacts on crops;
- Analysis of how to measure the different types of contaminations in groundwater;
- Examining how to combat groundwater contamination.

Following is the outline for this study. The second part explains in depth how this study examined and analyzed the various goals and data collected through literature. Section 3 then provides an in-depth examining of global groundwater potential for food production and a detailed description of the available different sources and types of groundwater in Asia, Africa and the American continent. Contaminations, causes of contaminations and their effects on crops, identification of various contaminations, and strategies for treating contaminations are also covered in Sections 4 and 5. Identification techniques of groundwater contamination are included in Section 6. Strategies to combat of groundwater from getting contaminated are discussed in Section 7 and the study's findings and way forward recommendations are summed up in Section 8.

2. Materials and Methods

In recent decades, natural and anthropogenic activities have significantly degraded the quality and composition of groundwater sources globally. Possibly one of the most important aspects of agriculture, the majority of global agricultural sectors rely directly or indirectly on groundwater resources for irrigation reasons. Consequently, the pollution and low quality of groundwater have an effect on agricultural output and are likely to exacerbate global food security challenges. As a consequence, governments across the globe are working on decreasing the pollution of groundwater sources and implementing contamination prevention techniques. Through their research, examining, and implementation of strategies and policies to address these issues, they play a significant role in addressing these issues through the conduct of critical research on combating this problem through the identification of different methods for different groundwater contaminations and prevention and treatment methods.

These studies were done in four distinct phases. The objective of Stage 1 of this research was to conduct a comprehensive systematic online literature review to examine the different sources and types of groundwater potential in the globe with three major groundwater potentials such as Asia, Africa and America. The online literature included articles from scientific databases (Science Direct, Scopus, and Google Scholar), as well as books, university reports, and periodicals. We obtained university publications through their books, university reports, and university publications regarding the groundwater pollution in various ways and the associated problems with food insecurity issues. This information needed to be as up-to-date as possible and include all relevant details. The timeliness of some of the available data was inadequate. More than 200 of studies have been included in the literature survey, but 77 of those were not relevant to the objectives of the review and out of date; therefore, those have been excluded.

In Stage 2 of this paper, the initially identified sources of contaminations and various contaminations types were taken into account, and the negative effects of these contaminations on the growth, efficiency, and yield production of crops are evaluated using previous studies. Additionally, the prevention of adding these contaminations to groundwater and treatment methods of contaminated groundwater prior to use for irrigation purposes are investigated. In stage 3 of this research, the obstacles of utilizing groundwater for irrigation, as well as the preventive and treatment strategies for groundwater, were analyzed based on the existing prior research. In the subsequent stage 4, the conclusion and future steps were analyzed and described.

3. Groundwater Potential in the Globe

Despite the fact that water makes up around 71% of the Earth's surface, 97% of all water is actually located in the ocean, where it is much too salty for human consumption and agricultural utilization [17]. Therefore, approximately 3% of the water on Earth is freshwater, and of that, 2.5% is not usable since it exists in glaciers, polar ice caps, atmosphere, and soil [18]; therefore, only around 0.5% of the water on Earth is usable fresh water and 98% of the fresh water comes from groundwater [19]. Aquifers are underground layers of water bearing rock or geological structures that produce sufficient groundwater for wells and springs [20]. Constrained aquifers are also known as artesian aquifers, which are often found at the foot of constrained rock strata. The water levels of fractured wells that draw water from artesian aquifers change more due to pressure fluctuation than quantity of stored water [21].

The availability of groundwater for agricultural use is highly variable around the globe, depending on factors such as climate and hydrogeological conditions. However, it also relies on the extraction tactics adopted, water quality, and the degree to which groundwater and surface water are interconnected and interdependent [22,23]. Hence, local water quality issues such as hardness, heavy metals, fluoride content, and salinity, groundwater sources are competitive with surface water for the irrigation. In addition to that, groundwater with enough storage capacity is an excellent multi-annual buffer as a water source for agriculture and can provide a considerable opportunity to ameliorate recurrent rainfall deficits in the less rainfall-receiving areas [24]. In some parts of the globe, deep groundwater basins are also utilized because of their high productivity, lack of sensitivity to pollution, and the artesian conditions that financially and technically advantageous. In the dry and semi-arid zone, renewable groundwater resources are less abundant and of varying but typically restricted scales [25]. However, they are often the sole permanent local water supplies in some regions, unless the water is driven from dams and waterways.

In the humid tropical and equatorial zone, groundwater resources are normally copious, but their distribution is more irregular due to the presence of old geological formations that often compose aquifers with limited storage [26]. They can only compete with surface water for satisfying geographically dispersed demand, due to their typically superior qualities. Even if aquifers are available, permafrost conditions in the arctic and subarctic zones of the Northern Hemisphere severely limit the availability of groundwater supplies [26,27]. Permafrost conditions may extend to depths of several hundred meters, obstructing recharge and restricting access to groundwater. The groundwater potential of the Asian continent is the greatest in the world, followed by that of Africa and North America, and then by that of South America, Europe, and Australia in that order. Figure 1 shows the illustrative view of the groundwater potential with different continents [28]. Herein, the detailed description of the different countries' groundwater potential from multiple continents are included.

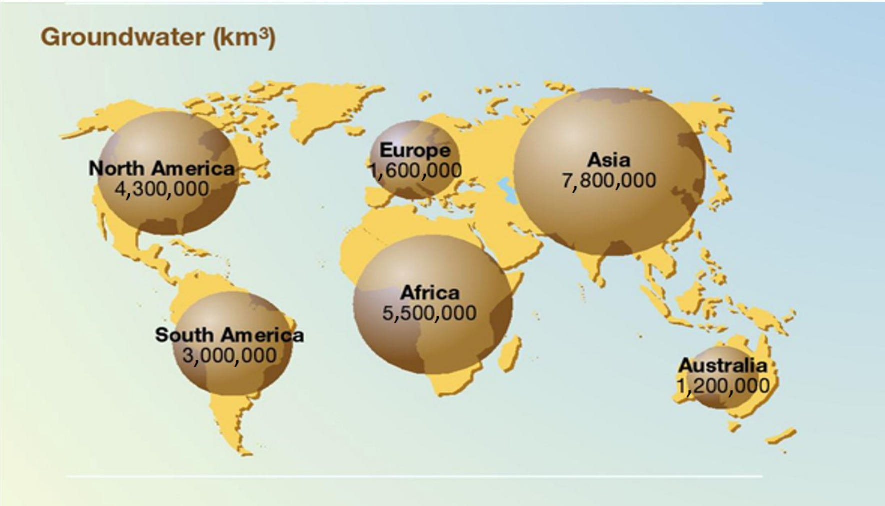

Figure 1. Groundwater potential of the globe with different continents [28].

3.1. Groundwater Potential for Food Production in Asia

Despite the fact that Asian countries have made great strides in eliminating malnutrition, the continent is still home to more than 550 million hungry people [27]. The area as a whole must enhance food production systems and distribution or face serious food security issues within the next century. Some emerging nations will need to boost their food output by up to 77% by 2050 in order to feed their citizens [27]. Lack of access to clean water is one of the identified causes in this region for the food security issues [29]. The combined landmass and high population of Asia (59.5% of the global population) lead to serious issues regarding the quality and quantity of assessed water source for food production and simulate food security issues.

Potential of available water is majorly dependent on the geography, climatic conditions and precipitations of the countries. Temperatures in Siberia's Arctic region contrast sharply with those of Southeast Asia and Southern India's tropical lowlands [30]. Inland areas of East Asia, Central Asia, and Western Asia are in the dry zone, whereas the coasts and islands of Southeast Asia and South Asia are dominated by the monsoon circulation [31]. Precipitation fluctuates geographically and climatically, while many regions of Southwest and Central Asia receive less than 150 mm of precipitation annually, some near the equator receive over 2000 mm [32]. Suitable water for the food production derives from surface water bodies, groundwater and rainwater. Groundwater is prioritized in the majority of Asian nations situated close to the equatorial zone since it may supplement water demands during drought. Along the banks of major rivers like the Ganges, Yangtze, and Mekong, sedimentary aquifers have formed, mostly made up of alluvial deposits from the floodplain [33]. Most of these aquifers are rather deep and thick, making them ideal for storing and distributing groundwater.

There are few areas in West Asia that can replenish groundwater in sedimentary aquifers and hard rock formations in the mountainous areas of Central and Northern Asia [34]. As glaciers and snow melt in the high mountains of Central Asia, they help replenish groundwater despite the dry climate and significant rates of evaporation in the inland [35]. Stratified limestone dating back to the Paleozoic and Mesozoic periods may be found in southern China and the Indochina peninsula, where karst systems are well-advanced [36]. The islands of the Pacific Ocean are underlain by a thick layer of Quaternary volcanic rock. In many parts of Asia, freshwater comes mostly from groundwater. Seven of the ten nations in the globe (India, China, Pakistan, Iran, Bangladesh, Saudi Arabia and Indonesia) with the highest rates of groundwater extraction are in Asia [37]. This is due largely to the fact that these countries are some of the most populated globally and have a great deal of agricultural activity. Nearly 80% of the water used in agriculture and industry in Bangladesh and Mongolia is pumped from the ground [38]. It is safe to say that groundwater is the primary renewable water supply for many nations in Western Asia, including Saudi Arabia, the United Arab Emirates, Oman, Kuwait, Bahrain, and Qatar, all of which lack permanent rivers.

Geologically, Sri Lanka has a great potential in terms of groundwater availability. More than 80% of the rural population depend on groundwater for their agricultural activities. The impact of climatic fluctuation on groundwater is substantially greater in the dry zone of Sri Lanka, which has a longer dry season and a shorter wet season. On the basis of their geo-hydrological properties, Sri Lanka is home to six primary kinds of aquifer systems: shallow karstic aquifers, coastal sand aquifers, deep restricted aquifers, lateritic (Cabook) aquifers, alluvial aquifers, and shallow regolith aquifers in the hard rock area [39].

3.2. Groundwater Potential for Food Production in Saudi Arabia

Both the rapid increase in the global population and climate change depleted natural resources and intensified water crises. Depletion of water resources directly affects agricultural production and escalates food insecurity. Under these circumstances, governments face pressure to establish a policy to lessen food insecurity by preserving water resources. Although several countries are confronting water crises, Gulf countries are highly susceptible to water insecurity. From this perspective, Saudi Arabia is trying to meet water demand by adapting various parameters such as the collection and recycling of wastewater, though not to a high extent, as shown in Figure 2. According to the World Bank report, in 2017 [40], Saudi Arabia produced 17% of water through the recycling of wastewater and 60% of water by collecting wastewater, which is less than other Gulf countries, as mentioned in Figure 1. Since 1980, water consumption in Saudi Arabia has increased by a factor of fifteen [41].

Saudi Arabia highly relied on groundwater and is considered an unsustainable water hotspot. Currently, depletion in groundwater coupled with pollution risks arises from agricultural activities, industrial and landfill wastes, and encroachment of the seawater degrading the quality of groundwater [42]. Despite being limitless, groundwater extraction for agriculture only contributed to 2% of the GCC country's GDP. Free allocation, the absence of water rights, and taxes provoked flood irrigation, which elevates evaporation. Several farmers used to cultivate water-intensive crops that can be imported at reasonable prices. In Eastern Saudi Arabia, high water pumping has disorganized the equilibrium between aquifers, which could adversely affect water quality through leakage of low-quality water from one aquifer to another [43]. Domestic consumption also causes water stress as the authors of [44] reported that almost 300 L of water per capita are consumed in Saudi Arabia. Inappropriate practices depleted 88% of groundwater in Saudi Arabia, as Figure 3 shows [40].

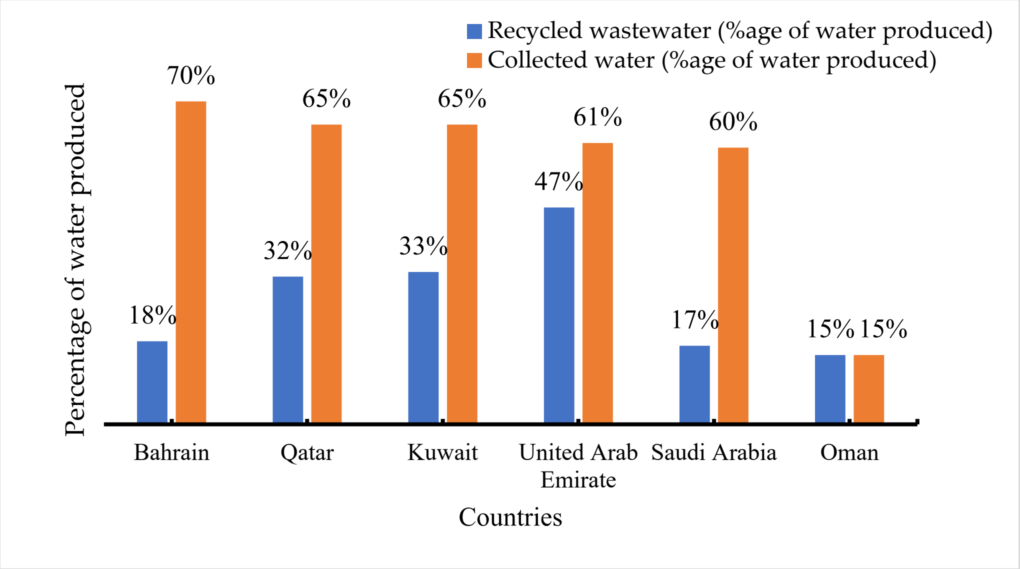

Figure 2. Collected and recycled wastewater as a percentage of produced wastewater [40].

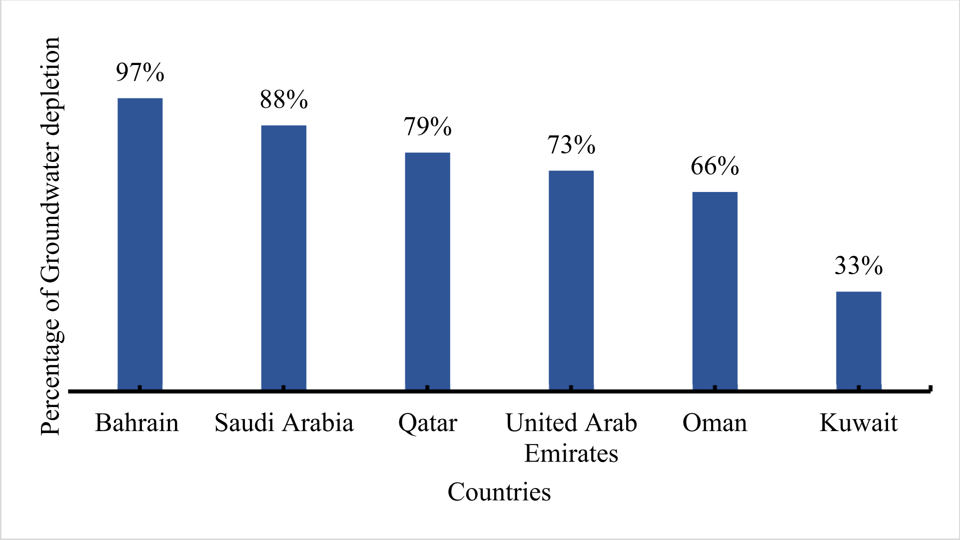

Figure 3. Groundwater depletion in GCC countries [45].

Groundwater is an important input for agricultural production. Depletion of groundwater directly affects food production and creates food insecurity. According to the Food and Agricultural Organization, the import dependency ratio in Saudi Arabia exceeded more than 95% [45]. From 1960–1990, KSA expanded irrigated lands from 0.37 million hectares to 1.5 million. Economical energy, innovative technologies, and flexible subsidies allowed growers to install deep wells and pump billions of cubic meters of water every year; in return, Saudi Arabia produced little GDP and high food insecurity [4]. According to FAO [46], the agricultural sector in Saudi Arabia is still consuming high amounts of groundwater. The Saudi National Water Strategy 2030 has suggested substantial modifications in agricultural activities to minimize water allocation to the farming sector. Groundwater depletion could increase food insecurity and decrease local production in Saudi Arabia, as Dawoud [45,47] reported that the population of GCC is highly reliant on desalinated plants and urban water supply, which is currently at risk of pollution and disaster. Such a situation could escalate security risks. If the supply is broken up, Saudi Arabia could only store clean water for three to five days. Additionally, there is not sufficient water supply to fulfill population demand during disaster conditions.

3.3. Groundwater Potential for Food Production in Africa

Africa corresponds to the more than half of the food insecurity issues of the globe. Across the continent, food production and food security are both threatened by a lack of water. Groundwater irrigation is one intriguing option that deserves further investigation. The industry is expanding, and as surface water becomes more unpredictable, farmers will benefit from the added security it offers. Only 1% of Africa's agricultural land is now fitted for groundwater irrigation, but that number is 14% in Asia [48]. The potential to enhance usage for irrigation is fairly considerable since there is a substantial groundwater storage in many sections of the continent.

Many of Africa's groundwater resources are located in the continent's massive sedimentary aquifers found in the northern part of the continent. The largest quantities of groundwater are found in Libya, Algeria, Sudan, Egypt, and Chad, respectively [49]. Important groundwater reservoirs can be found in the Taoudeni-Niger region [50], the Libyan Desert, the Chad region, and the Kalahari, all of which are large inland depressions in Africa's basement rock filled with sedimentary layers of continental origin [51]. East African plateaus typically have few groundwater reserves [52]. The Continental Intercalary series, which includes the Nubian sandstones of southern Egypt, is the most significant water-bearing layer in the Sahara [53]. The Precambrian bedrock may be seen right through to the surface in certain parts of Sudan [54]. Aquifers are located in sandstone, limestone, and sand and gravel deposits in the coastal regions of African countries including Senegal, Ghana, Nigeria, Cameroon, Mozambique, the East African republics, and Madagascar [55]. Water is found in abundance in the Jurassic limestones of the Maghrib's hilly region as opposed to the dolomitic limestones found elsewhere [56]. Water yields from porous aquifers may range from only a few cubic feet per hour in the fine-grained sands prevalent over most of the continent to hundreds of cubic feet per hour in the course gravels of the Nile delta [57]. Limestones in North Africa with plenty of fissures and fractures may produce thousands of cubic feet of water every hour, whereas in the Democratic Republic of the Congo, Zambia, and South Africa, dolomitic limestones produce high volumes of water [58]. In places such as North Africa, Mozambique, Ethiopia, and South Africa, where groundwater comes from deeper sea strata, there may be a lot of salts in it [59].

3.4. Groundwater Potential for Food Production in North America

An estimated 10.2% of the human population in North America are food insecure. In the United States, almost 165 million of the population uses groundwater for irrigation. Approximately 54% of the entire groundwater potential is used in agriculture [60]. Southern Mexico and the coastal regions of the United States and Canada are characterized by copious precipitation, in contrast to the dry desert landscapes of the Southwestern United States and Northern Mexico [61]. Increasing population density across the continent has accelerated the freshwater scarcity issues and creates a significant challenge to North American water management for irrigation. Canadians are fortunate to have a higher amount of high-quality groundwater through numerous aquifers in Canada being located in deposits of sand and gravel generated by glacier-melting rivers or lakes [53]. The Carberry aquifer is a major source of agricultural irrigation water in Manitoba [62].

A significant sand and gravel aquifer in the Fraser Valley of British Columbia is frequently exploited for irrigation and other household needs [63]. Underneath the soil of Prince Edward Island, a thick, broken sandstone structure contains the island's entire water supply [64]. Aquifers are composed of thick alluvial deposits in the Central Valley of California, the high plains, and the Mississippi River alluvium; glacial drift deposits in the North Central and Northeastern United States [65]; unconsolidated sediments of the Atlantic and Gulf Coastal Plains; consolidated limestones and dolomites in the Florida peninsula and adjacent coastal regions, as well as Texas and New Mexico; and sandstones in the Appalachian Mountains [65,66].

Fresh groundwater withdrawals are mostly utilized for agriculture and animals. Groundwater quality in the United States varies greatly from location to location [67]. In contrast, groundwater from sandstone, shale, and limestone strata in the midcontinent is very hard, rich in dissolved particles, and alkaline. Despite the fact that the United States is endowed with relatively substantial quantities of groundwater, local and regional overdrafts of groundwater reserves have already resulted in several negative consequences. These include the lowering of water tables, the infiltration of saline water, land subsidence, and the reduction of stream base flow. In Mexico, the National Water Commission has recognized 653 aquifers [68]. The first is the Trans Volcanic Belt of Mexico, which is comprised of steep mountains and intermontane valleys with thick lacustrine deposits [69].

4. Different Contaminations of Groundwater Impact on Food Security

Food production relies heavily on irrigation; thus, it is crucial that the water being used for that purpose be of high quality. There are several factors that influence the groundwater quality to ensure the safer food production such as soluble salts, pH and alkalinity, trace/heavy metals. Before acquiring groundwater for irrigation purposes, it is necessary to comprehend its true quality and chemical compositions. The available compositions may be compared to the needed water quality, and if anything deviates from the standard, the appropriate treatment process can be made more suitable for agriculture. Poor quality of water causes sluggish development, low aesthetic quality of the crop, and in certain situations, the progressive demise of the crops [70].

High soluble salts will directly harm the roots of the vegetation by interfering with their absorption of water and nutrients. Salts may build at the leaf margins, causing the edges to burn [71]. High alkalinity will alter the pH of the water source and affect the growth medium, interfering with nutrient absorption and creating of nutritional deficiencies that are detrimental to plant health [72]. There may be harmful organisms, residues of organic and inorganic soluble and non-soluble salts present in groundwater, which need reconditioning before irrigation [73]. The detailed study for each compositions and the impacts on crops are described.

4.1. Soluble Salts of the Groundwater

A soluble salts concentration in groundwater will be determined by its electrical conductivity (EC). Groundwater with a high EC may result from a number of sources such as fertilizer-rich confinement, water polluted by road salt, and saltwater intrusion in coastal wells [74]. To prevent plant damage, EC should be no greater than the permissible range of 0–1.5 mS/cm [75]. Root function is impaired by an excess of soluble salts, which may limit water intake and cause nutritional shortages [76]. Calcium concentrations between 40–100 ppm and magnesium concentrations between 30–50 ppm are deemed appropriate for irrigation [77]. Irrigated groundwater with a high Ca and Mg concentration leaves behind hard water deposits, reducing the efficiency of the water supply to plants over time [66]. This has a significant impact on the agricultural field water distribution system, especially in micro irrigation systems. They may lead to a buildup of salt in the soil, which stops plants from absorbing water effectively. This leads to an inability to flourish and the symptoms include sluggish new growth, yellow or brown-edged leaves, and even withering [78].

Groundwater irrigation with excessive Na and Cl is directly hazardous to plants, leads to an increase in the number of soluble salts in the growth media, and hinders water absorption [79]. Excess soluble salts cause damage to plants, stunt growth, and increase susceptibility to disease. Foliar chlorosis induced as a result of excessive Na and Cl resembles that caused by N, Fe and Mg shortages [80]. High salt inhibits calcium absorption by plants and may cause excessive calcium and magnesium leaching from growth conditions [81]. In addition, sodium may be absorbed via the leaves, leading in leaf burn [82]. Sodium-rich groundwater may also include high chloride concentrations and causes excessive foliar absorption under overhead irrigation or leaf edge burn in vulnerable plants [83]. Depending on crop sensitivity, acceptable amounts of Na and Cl for ornamentals are fewer than 50 ppm and 140 ppm, respectively [84]. However, higher concentrations may be tolerated. Concentrations of sodium below 50 ppm are appropriate for overhead irrigation [85]. Potassium and phosphate are essential to plant nutrients that are often present in extremely low concentrations in groundwater [86]. Groundwater used for irrigation may be tainted with fertilizers or other pollutants if concentrations of more than a few parts per million are found.

4.2. pH and Alkalinity

The alkalinity and acidity levels of groundwater are crucial in deciding whether or not it may be used for irrigation. pH levels in irrigation water should be between 5.0 and 7.0 [87]. The aquifer's geological components, such as limestone and dolomite, leach these chemicals into the water. Irrigation water quality is optimal between 0 and 100 ppm calcium carbonate. High alkalinity has the greatest impact on the fertility of the growth medium and the nourishment of the plants [88]. As long as the alkalinity is minimal, water with a high pH may be safely used for irrigation. Growing plants in tiny pots exacerbates the pH and alkalinity management issues since the soil in such containers is less able to resist a shift in pH [89]. Due to this, plug and seedling trays are especially vulnerable to the effects a high pH and high alkalinity. Using water with a high alkalinity may cause deficits in trace elements like iron and manganese, as well as Ca and Mg imbalances.

Carbonates and bicarbonates may build up in the nozzles of pesticide sprayers and micro irrigation systems, which can have disastrous results. The high alkalinity of water significantly reduces the efficacy of several insecticides, floral preservatives, and growth regulators. If the chemical needs a pH below 7.0 and the pH of the groundwater is over 7.0, a buffering agent must be added to the water before it can be used [89].

4.3. Trace or Heavy Metals

Due to the pervasive and chemically stable nature, toxicity and potential for bioaccumulation of the trace or heavy metals, their presence in groundwater has attracted considerable interest for decades [90]. Main sources for heavy metals include local geology from weathered rocks and minerals, municipal solid waste, and agricultural chemicals. The most frequent metals in groundwater are manganese (Mn), copper (Cu), lead (Pb), sodium (Na), nickel (Ni), aluminum (Al), and zinc (Zn). The buildup of trace elements or heavy metal toxicity might deplete plant-harmful nutritional components. Ni, Cu, and Cd may cause Fe chlorosis in a number of plant species. To confirm a case of metal/nutrient poisoning, it must be determined that plants have been harmed, that an accumulation of a potentially phytotoxic element has occurred in the tissue, and that the element is responsible for the abnormalities [91].

4.4. Impact of Groundwater Contamination on Agri-Food Systems

Contaminations from the agro-farm industries are also significantly responsible for the deterioration of the quality of groundwater; in some cases, such as the banana industry in tropical countries (Panama and Venezuela), it can have significant impacts on soil properties such as soil consistence, biological activity, and HCl [92], pathogen incidence such as the soil fungus Fusarium wilt and fungus-bacteria complexes capable of proliferating under poorly drained conditions [93], and banana productivity associated with the absence of soil and water conservation practices in lacustrine and alluvial soils [94]. One major source of water pollution in the banana industry is the use of pesticides and fertilizers. These chemicals can leach onto nearby water sources and negatively affect the health of the soil, plants, and local aquatic ecosystems.

In terms of soil properties, water pollution from pesticides and fertilizers can lead to a decline in soil fertility and microbial activity [95]. This can result in reduced banana productivity, as the plants may not be able to access the necessary nutrients for growth. Additionally, the chemicals can also lead to soil erosion, which can further degrade soil quality. Pathogen incidence is another area that can be affected by water pollution from the banana industry [92]. Pesticides and fertilizers can disrupt the balance of the local ecosystem, allowing pathogens to thrive. This can lead to an increase in diseases and pests that can harm banana plants, reducing productivity and yield.

In terms of banana productivity, water pollution can have a significant negative impact. The chemicals can damage the health of the plants, leading to reduced growth and yield. Additionally, the disruption of the soil ecosystem can also lead to reduced productivity [92]. Overall, to mitigate these impacts, it is important to implement sustainable farming practices that minimize the use of pesticides and fertilizers, and that promote soil health and the local ecosystem.

5. Sources of Contamination in Groundwater

The addition of undesired elements to groundwater as a result of natural or human activity is referred to as groundwater contamination including chemicals, road salt, bacteria, viruses, drugs, fertilizers, and gasoline [96]. However, groundwater pollution varies from surface water contamination in that it is undetectable and impossible to recover the resource at the present technological level. Groundwater contaminants are often odorless and colorless. An inefficient irrigation system with contaminated water can lead to it being incapable of providing the optimal soil–water–nutrient environment for crop growth. This will result in lower yields, lower quality, or higher expenses per unit of production compared to good quality irrigation and will also create health issues for the consumers after having the food cultivated by contaminated water.

Groundwater is found in underground geological layers and has extended residences' durations, making cleanup difficult and expensive. Even if the source of pollution is eliminated, it might take decades or even centuries for polluted groundwater to be purified by natural means [97]. The number of pollutants identified in groundwater is categorized as chemical contaminants, leachate from landfills and sewages and biological contaminants. These pollutants may originate from natural or human-made sources if human activities disturb the natural environmental equilibrium, such as the depletion of aquifers leading to saltwater intrusion, acid mine drainage as a result of mineral resource extraction, and leaching of hazardous chemicals as a result of excessive irrigation.

5.1. Chemical Contamination of Groundwater

Common inorganic pollutants include nitrate, nitrite, and ammonia nitrogen mostly derived from anthropogenic sources, such as agricultural fertilizers, manure, and domestic wastewater. Anions and oxyanions, such as F, $SO_4{}^{2-}$, and Cl, as well as significant cations, such as Ca^{2+} and Mg^{2+}, are other prevalent inorganic pollutants found in groundwater [98]. Groundwater may also have an increase in total dissolved solids (TDS), which is the sum of all the ligands present in water [99]. The majority of these pollutants have a natural origin, but human activities may potentially increase their concentrations in groundwater.

Toxic metals and metalloids pose a threat to both human and environmental health. Metals, including zinc (Zn), lead (Pb), mercury (Hg), chromium (Cr), and cadmium (Cd), and metalloids, including selenium (Se) and arsenic (As), are often identified in groundwater [100]. At lower concentrations, several of these elements serve as necessary micronutrients, but at higher concentrations, they are hazardous. Exposure to hexavalent chromium (Cr^{6+}) may raise the risk of cancer, whereas As^{3+} can react with the sulfhydryl (–SH) groups of proteins and enzymes to disrupt cellular activities and ultimately induce cell death [101].

Toxic metals in the environment are persistent and bio-accumulate modestly when they enter the food chain.

Numerous organic pollutants have been found in groundwater. The majority of biodegradable organic pollutants come from sewage and industrial effluent. Bacteria have the potential to transform many of these unstable organic compounds into stable inorganic substances such as carbohydrates, proteins and lipids. They may diminish the concentrations of dissolved oxygen in groundwater and create biological oxygen demand (BOD) [102]. Hydrocarbons, halogenated chemicals, plasticizers, pesticides, medicines, and personal care products, are among the most prevalent organic pollutants [103]. Chlorinated, brominated, and fluorinated substances, among others, are persistent in the environment and may collect and enrich in organisms, leading to detrimental repercussions in species from higher trophic levels, including humans [104].

5.2. Leachate from Landfills and Sewages

Leachate from landfills is one of the primary pollutants generated by landfills. The leachate may include soluble and insoluble organic and inorganic substances that are the outcome of physical, chemical, hydrolytic, and fermentation activities [105]. Contamination of groundwater is inevitable when the landfill's base is below the water table or when the barrier between the trash and the aquifer is permeable. Waste composition, weather, site hydrology, trash compaction, waste age, landfill technology, and monitoring methods all play significant roles in determining the types and quantities of pollutants found in landfill leachate [106]. Various pollutants, including organic debris, inorganic macro components, heavy metals, and xenobiotic organic compounds, are leached from landfills [107]. The stage of stability of a landfill, which shows the age of the landfill, regulates the quality of leachate, which in turn influences the amount of groundwater pollution.

The disposal of wastewater in workplaces, houses, and the majority of other structures requires the use of septic systems. There is always a potential that the septic system in the house or workplace has been improperly planned, maintained, or installed, despite the fact that these systems have been intended to allow for the gradual draining of human waste at a safe pace. If so, the system might break and leak, allowing pathogens, chemicals, and germs to enter the groundwater in the area. When this happens, the local ecology will almost certainly deteriorate, which might lead to problems with irrigation and health problems for the local population.

5.3. Biological Contamination of Groundwater

Algae and microorganisms, including bacteria, viruses, and protozoa, are examples of biological pollutants [108]. Some of these microorganisms are derived from natural sources, but others are microorganisms that coexist with native algal species and compete for available nutrients. Many human illnesses, particularly severe diarrheal disorders such as typhoid and cholera, may be caused by ingesting microbial contaminated groundwater irrigated food products.

Solid waste contaminated with human and liquid excreta, which may include numerous harmful microorganisms such as bacteria and viruses, is often disposed of in landfills, open dumping sites, and areas with unlined drains. Harmful chemicals, nutrients, and pathogenic bacteria contaminate the groundwater environment by seeping into the groundwater aquifer. The most common ways in which animal feces contaminate groundwater are through the leakage or overflow of manure storage piles or lagoons at animal feeding operations (feedlots) and concentrated animal feeding operations, the application of improperly treated wastewaters associated with food processing or animal slaughter, and the wastes of pets, livestock, and wild animals [109]. Surface and subsurface sources also contribute to fecal pollution. Facial tissues, pet excrement that may carry human pathogenic viruses, soiled disposable diapers, and spoiled foods are only a few examples of highly infectious home wastes. It can be shown from the ratio of fecal coliform to fecal streptococci in landfill rubbish that the bulk of pathogens in municipal waste is not from humans but rather from other warm-blooded animals [110]. Overflowing or seeping septic tanks are among the most often documented forms of groundwater pollution associated with disease outbreaks.

6. Identifications of Contamination in Groundwater

The identification of contaminants in groundwater analysis is of growing relevance in the monitoring of groundwater quality of irrigation for agriculture to achieve the food security with quality of food products. Recently, there has been a rise in the production of groundwater quality sensors and the development of consensus on where to place sensors for optimal event detection. Groundwater quality may be monitored for things such as temperature, pH, turbidity, conductivity, oxidation reduction potential (ORP), UV-254, nitrate-nitrogen, and phosphate by installing sensors in distribution systems [111]. To determine the presence of pollutants in the groundwater, precise and rapid detection methods are required. As several kinds of pollutants may be present, proper qualitative and quantitative analysis requires the use of efficient methodologies.

Laboratory and field analytical procedures for biological and non-biological contaminants are distinct. Various potable detection technologies are being considered widely as potential solutions [23]. It is currently possible to create labs on a chip that sample, filter, pre-concentrate, separate, and detect biomolecules or analytes using negligible volumes of liquid [112]. The infrared (IR) and Raman spectrometers are the most often utilized vibrational spectroscopy equipment in groundwater monitoring technologies [113]. The most prevalent techniques for identifying pollutants in groundwater include discontinuous approaches, in-line sensor-based monitoring, and algorithmic model-based event detection [114]. Indicator organisms are used to identify the pathogenic microbiological characteristics of the water. Despite the advancement of novel methods, traditional culture-based approaches are still utilized for the identification of microbiological characteristics in groundwater [115].

7. Methods of Combating the Groundwater Contamination

7.1. Prevention of Contaminating Mixing with Groundwater

Although groundwater is a priceless natural resource, it is becoming unsafe to consume due to pollution and contamination. As it is important to know which kinds of contaminants are in the groundwater, it must be equally important to take measures to avoid them from mixing with the water supply. Contamination of various nitrogen sources is the given priority in groundwater quality parameters [16]. Nitrate level of each groundwater source points should be identified. Nitrate levels in the environment may be lowered by regulating wastewater management, eliminating the discharge of municipal and industrial waste into treatment systems and municipal sludge, and removing bio solids liquids [116].

There are a number of ways to counteract the impact of heavy metal deposition in groundwater. Isolation methods attempt to isolate toxins inside a specified region to avoid their spread [117]. When alternative remediation solutions are not physically or financially possible for a location, these technologies may be used to avoid additional groundwater pollution. During the assessment and remediation of contaminated sites, they may also be isolated for a period of time to limit transport. By altering the physical or leaching characteristics of the contaminated matrix, immobilization technologies aim to reduce the mobility of contaminants. Physically limiting the contamination interaction with the surrounding groundwater or chemically modifying the contaminant to make it more stable in groundwater are the most prevalent methods for reducing mobility [118]. Enacting and enforcing the appropriate rules is necessary to manage the rising waste levels in the country while avoiding environmental degradation. It is required to execute an integrated waste management plan consisting of a hierarchical and coordinated set of pollution-reduction measures [119]. To limit the effect of these dumps on groundwater quality and the environment as a whole, these facilities must be designed and constructed to avoid contamination. Long-term monitoring is essential to determine the effect of seasonal fluctuations on pollutant concentrations throughout time [120].

In addition, the need for sanitary landfills is necessary to prevent the pollution of groundwater by waste leachate. Extending the lifespan of landfills and diverting as much garbage as feasible via waste avoidance, reuse, recycling, and composting may be cost-effective. In addition to providing employment, decreasing poverty, enhancing economic competitiveness, lowering pollution, and preserving natural resources, diverting items from landfills may contribute to reducing pollution and conserving natural resources. This may be achieved by guaranteeing the correct maintenance of saltwater barrages by the relevant authorities in order to limit the saltwater intrusion impact [121]. Continuing in this manner may exacerbate the impacts of saltwater intrusion. A significant element is the infiltration layer, which is the vertical distance between the latrine pit and the groundwater table. When the infiltration layer is thicker, the transmission period of pathogens is elongated, hence decreasing the danger of groundwater pollution [122]. Fecal contamination in groundwater may be accelerated or slowed down by a variety of factors unique to a given area, including the soil condition, the condition of the latrine pit, the condition of the groundwater extraction point, the land uses adjacent to the extraction point, the surface water flow pattern, and many others.

7.2. Advanced Technologies to Treat the Groundwater

The primary goals of the conventional contaminated water treatment process, such as activated sludge, are the elimination of biological and non-biological contaminations. The wide diversity, very low concentration, and distinctive properties of emerging contaminations are critical aspects in treating of contaminated water despite the fact that numerous treatment processes are followed in the water treatment plant, which may contribute to the removal of these contaminants. Endocrine disrupting chemicals (EDCs) have been linked to harmful effects on the human endocrine system, drawing focus to research into the removal or treatment of these micropollutants from groundwater. The remediation alternatives for contaminations in groundwater include adsorption technology, membrane technology, biological treatment, and the advanced oxidation approach.

Adsorption technology involves the mass transfer of substances between liquid–liquid, liquid–solid, gas–liquid, and gas–solid interfaces. With the aid of intermolecular interactions, adsorbents are used to remove certain pollutants (adsorbates) from groundwater [100]. There are two interactions between the solid surface and adsorbates: physisorption and chemisorption [100]. For the removal of contaminants from aqueous solutions, inexpensive and widely accessible agricultural solid wastes such rice husk and straw, fruit peels and stones have been used. Oxidation of the activated carbon significantly increased the hydrophilic nature of the material, which lowers the adsorption capacity and has a significant impact on the breakthrough times and adsorption capacity values in the fixed-bed adsorption process [123]. The inexpensive and easily accessible adsorbent would make a feasible option for treating polluted groundwater. Several environmental factors and variables, such as initial adsorbate and adsorbent concentration, adsorbent particle size, temperature, pH, selectivity, ionic strength, contact duration, and rotation rate, are employed to ensure the efficacy of the adsorption process [124].

Another potential approach for the effective removal of micropollutants from groundwater is membrane technology. This method employs both nonbiological and biological processes such as reverse osmosis, ultrafiltration, and nanofiltration [125]. Membrane bioreactors (MBRs) combine membrane-based filtration procedures, such as microfiltration (MF) or ultrafiltration (UF) technology, with biological reactors for suspended growth [126]. MBRs are the most prevalent and well-established procedures for obtaining generally clean groundwater by combining membrane and biological treatments. Non biological techniques or pressure-driven membrane technologies, such as reverse osmosis (RO), nanofiltration (NF), membrane filtration (MF), or ultrafiltration (UF), use high pressures across the membranes to filter pollutants from generated water [127]. Membrane techniques are thus suited for reducing turbidity and microbiological pollutants. However, high running expenses continue to restrict its widespread use. Membranes are susceptible to fouling issues, which may lead to unanticipated disruptions during the treatment of aqueous pollutants [128].

Biological treatment of the contaminated groundwater includes biodegradation and the adsorption process is also widely followed globally [126]. Typically, the biological treatment comprises an activated sludge process (ASP) and trickling filter (TF) [105]. After TF or ASP, dense microbial biomass is removed from secondary sedimentation [129]. The activated sludge system consists of a reactor, separator system and recycle system [130] and it is carried out by introducing air into the reactor and through the continual recirculation of biomass into the aeration tank [131]. Some forms of ASP have the advantages of reduced ammonia levels, short space requirements, and no odor [132]. However, aeration tanks demand a great deal of energy to operate, and the changes in effluent properties are somewhat inflexible. ASP is affected by variables such as oxygen availability, temperature, characteristics of treated water, detergents that generate foam, and return rate [108].

In ultrafiltration, however, microbial biomass develops on an inert or solid media in film form while continuous effluent is sprinkled over them [133]. Numerous advantages of this sort of biological treatment have been emphasized, including improved sludge thickening, low maintenance costs, reduced energy usage, and simplicity of operation [109]. However, the effluent quality of the TF system is inferior to that of suspended growth systems. The quality of TF effluent is determined by biochemical oxygen demand (BOD) and suspended solids (SS) [134]. Temperature, retention duration, type of medium and its depth, as well as hydraulic and organic matter are some elements that may influence the performance of the TF, resulting in a variation in the relative removal effectiveness of certain contaminants [135].

Pollutants may be degraded into safer and more biodegradable molecules via the use of advanced oxidation processes (AOP), which include the production of free radicals, most notably hydroxyl radicals [110]. Through the use of advanced oxidation processes (AOP), contaminants may be degraded into safer, biodegradable chemicals. To treat groundwater, AOPs are among the most efficient methods available. The chemical reaction known as photocatalysis happens when a catalyst is activated by the presence of light, which provides enough energy for the process to take place [136]. Semiconductor metal oxides with a narrow energy band gap are the most effective photocatalysts. The technology for oxidizing ozone oxidation is not very effective, and a large quantity of ozone is needed to totally breakdown organic molecules. Due to this, ozone oxidation technology is often used in tandem with other methods [137]. Ozone oxidation technique, when coupled with ultraviolet light (O3/UV), is effective in degrading a wide range of organic molecules at a rapid pace and removing complicated organic debris [138].

8. Conclusions and Way-Forward

Food security is a vital need for all nations; as a result, diverse management and strategies are used by each country to ensure food security. Food insecurity will have a myriad of negative repercussions on a population if governments fail to address it in an acceptable way. Numerous countries have a long history of agriculture and food production. As a result of a rapidly expanding population and the accompanying urbanization, there are fewer resources available for safer, higher-quality agriculture, which has accelerated food insecurity. Despite the importance of irrigation to agriculture, water scarcity is a severe hurdle. Mismanagement of groundwater resources and groundwater contamination compound the issue.

Despite the vast and varied uses of groundwater around the world, this resource is poorly understood, often mismanaged, and subject to unclear ownership and management requirements. Groundwater must be recognized as a critical resource for the sustained development and agricultural sustainability of nations worldwide. Future management will need the creation of a global monitoring program for the quantity and quality of groundwater, as well as a comprehensive database. Additionally, a better and more consistent understanding of groundwater–surface water interactions, increased conjunctive uses, and the link between groundwater and aquatic and terrestrial ecosystems is required. The preservation of sensitive and important groundwater resources from overexploitation and pollution, as well as the maintenance and improvement of drinking water supplies and sewage and sanitation infrastructure, are all crucial. Public awareness, intellectual interest, and institutional responses to groundwater management are on the rise.

In this article, the available global groundwater potential for food production in different continents, such as Asia, Africa, and North America, as well as the different sources of groundwater and their classification, different contaminations of the groundwater and their impact on crops, sources of contamination of groundwater and how to treat contaminated groundwater, and preventative measures against groundwater contamination were examined. Inadequate concern for a coordinated effort, such as laws and regulations, the formation of a coherent water strategy, and the decentralization of authority remain important obstacles to the management of aquifer resources. The sensitive groundwater-irrigation based agriculture systems is of concern within the context of agricultural and food policy of the global countries. The government of the countries, international funders, and the scientific community should offer financial and institutional assistance for further research and development studies related to safer groundwater for irrigation.

Author Contributions: Conceptualization, A.M.M.I. and M.M.M.N.; methodology, A.M.M.I. and M.M.M.N.; software, B.A.A. and A.T.; validation, A.T.; formal analysis, A.M.M.I.; investigation, B.A.A. and M.M.M.N.; resources, B.A.A.; data curation, A.T. and M.M.M.N.; writing—original draft preparation, A.M.M.I. and M.M.M.N.; writing—review and editing, A.T.; visualization, B.A.A.; supervision, M.M.M.N. and B.A.A.; project administration, A.M.M.I.; funding acquisition, A.T. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Researchers Supporting Project Number (RSP2023R443), King Saud University, Riyadh, Saudi Arabia.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The authors extend their appreciation to The Researchers Supporting Project number (RSP2023R443) King Saud University, Riyadh, Saudi Arabia.

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

References

1. Pawlak, K.; Kołodziejczak, M. The Role of Agriculture in Ensuring Food Security in Developing Countries: Considerations in the Context of the Problem of Sustainable Food Production. *Sustainability* **2020**, *12*, 5488. [CrossRef]
2. Bechoff, A.; Shee, A.; Mvumi, B.M.; Ngwenyama, P.; Debelo, H.; Ferruzzi, M.G.; Nyanga, L.K.; Mayanja, S.; Tomlins, K.I. Estimation of nutritional postharvest losses along food value chains: A case study of three key food security commodities in sub-Saharan Africa. *Food Secur.* **2022**, *14*, 571–590. [CrossRef]
3. Kemmerling, B.; Schetter, C.; Wirkus, L. The logics of war and food (in)security. *Glob. Food Secur.* **2022**, *33*, 100634. [CrossRef]
4. Touidjeni, Z.; Boufalta, M.S.E.; Mebarki, L. The food security of Algerian households in the light of the COVID-19 pandemic: An exploratory study. *Int. J. Food Agric. Econ.* **2022**, *10*, 185–203.
5. Gingell, T.; Murray, K.; Correa-Velez, I.; Gallegos, D. Determinants of food security among people from refugee backgrounds resettled in high-income countries: A systematic review and thematic synthesis. *PLoS ONE* **2022**, *17*, e0268830. [CrossRef]
6. Zhong, T.; Crush, J.; Si, Z.; Scott, S. Emergency food supplies and food security in Wuhan and Nanjing, China, during the COVID-19 pandemic: Evidence from a field survey. *Dev. Policy Rev.* **2022**, *40*, e12575. [CrossRef]
7. Affoh, R.; Zheng, H.; Dangui, K.; Dissani, B.M. The Impact of Climate Variability and Change on Food Security in Sub-Saharan Africa: Perspective from Panel Data Analysis. *Sustainability* **2022**, *14*, 759. [CrossRef]
8. State of Food Security and Nutrition in the World (SOFI). The State of Food Security and Nutrition in the World (SOFI). Repurposing Food and Agricultural Policies to Make Healthy Diets More Affordable. 2022. Available online: https://www.fao.org/publications/sofi/2022/en/ (accessed on 10 November 2022).
9. Garvey, M. Bacteriophages and Food Production: Biocontrol and Bio-Preservation Options for Food Safety. *Antibiotics* **2022**, *11*, 1324. [CrossRef]

10. Xu, F.; Baker, R.; Whitaker, T.; Luo, H.; Zhao, Y.; Stevenson, A.; Boesch, C.; Zhang, G. Review of good agricultural practices for smallholder maize farmers to minimise aflatoxin contamination. *World Mycotoxin J.* **2022**, *15*, 171–186. [CrossRef]
11. Wijerathna-Yapa, A.; Pathirana, R. Sustainable Agro-Food Systems for Addressing Climate Change and Food Security. *Agriculture* **2022**, *12*, 1554. [CrossRef]
12. Cole, M.B.; Augustin, M.A.; Robertson, M.J.; Manners, J.M. The science of food security. *npj Sci. Food* **2018**, *2*, 14. [CrossRef]
13. Wang, X. Managing Land Carrying Capacity: Key to Achieving Sustainable Production Systems for Food Security. *Land* **2022**, *11*, 484. [CrossRef]
14. Kosanke, R.M. Effective use of water in irrigated areas. *Orient Renaiss. Innov. Educ. Nat. Soc. Sci.* **2019**, *2*, 810–815.
15. Cosgrove, W.J.; Loucks, D.P. Water management: Current and future challenges and research directions. *Water Resour. Assoc.* **2015**, *51*, 4823–4839. [CrossRef]
16. Parizad, S.; Bera, S. The effect of organic farming on water reusability, sustainable ecosystem, and food toxicity. *Environ. Sci. Pollut. Res.* **2021**, *28*. [CrossRef] [PubMed]
17. Issac, M.N.; Kandasubramanian, B. Effect of microplastics in water and aquatic systems. *Environ. Sci. Pollut. Res.* **2021**, *28*, 19544–19562. [CrossRef] [PubMed]
18. Sanogho, M.B.Y. Nestlé and the Right to Water. *J. Int. Relat. Peace Stud. Dev.* **2022**, *7*, 8.
19. Patel, P.; Patel, A. Low cost model for desalination of water using solar energy to overcome water scarcity in India. *Mater. Today Proc.* **2021**, *47*, 1409–1415. [CrossRef]
20. Pozilov, M.N.; Qurbanova, L.M. The Structural-Hydrogeological Analysis of Formation of Underground Waters. *Eurasian Res. Bull.* **2022**, *8*, 13–18.
21. Chaudhari, A.N.; Mehta, D.J.; Sharma, N.D. Coupled effect of seawater intrusion on groundwater quality: Study of South-West zone of Surat city. *Water Supply* **2022**, *22*, 1716–1734. [CrossRef]
22. Werner, A.D.; Sharp, H.K.; Galvis, S.C.; Post, V.E.; Sinclair, P. Hydrogeology and management of freshwater lenses on atoll islands: Review of current knowledge and research needs. *J. Hydrol.* **2017**, *551*, 819–844. [CrossRef]
23. Elshall, A.S.; Arik, A.D.; I El-Kadi, A.; Pierce, S.; Ye, M.; Burnett, K.M.; Wada, C.A.; Bremer, L.L.; Chun, G. Groundwater sustainability: A review of the interactions between science and policy. *Environ. Res. Lett.* **2020**, *15*, 093004. [CrossRef]
24. Hellwig, J.; Stahl, K. An assessment of trends and potential future changes in groundwater-baseflow drought based on catchment response times. *Hydrol. Earth Syst. Sci.* **2018**, *22*, 6209–6224. [CrossRef]
25. Horan, R.; Wable, P.; Srinivasan, V.; Baron, H.; Keller, V.; Garg, K.; Rickards, N.; Simpson, M.; Houghton-Carr, H.; Rees, H. Modelling Small-Scale Storage Interventions in Semi-Arid India at the Basin Scale. *Sustainability* **2021**, *13*, 6129. [CrossRef]
26. Peng, T.-R.; Huang, C.-C.; Wang, C.-H.; Liu, T.-K.; Lu, W.-C.; Chen, K.-Y. Using oxygen, hydrogen, and tritium isotopes to assess pond water's contribution to groundwater and local precipitation in the pediment tableland areas of northwestern Taiwan. *J. Hydrol.* **2012**, *450–451*, 105–116. [CrossRef]
27. Food and Agriculture Organization (FAO). Crop Prospects and Food Situation. Quarterly Global Report No. 2, July 2022. Rome, Italy. 2022. Available online: https://www.fao.org/giews/reports/crop-prospects/en/ (accessed on 14 January 2022).
28. Rekacewicz, P. Freshwater Resources: Volume by Continent. GRID ARENDAL. Published 2022. Available online: https://www.grida.no/resources/5608 (accessed on 14 January 2022).
29. Food and Agriculture Organization. The State of Food and Agriculture: Women in Agriculture. 2013. Available online: http://www.ncbi.nlm.nih.gov/pubmed/24897208%5Cnhttp://www.fao.org/catalog/inter-e.htm (accessed on 21 December 2022).
30. de Jager, A.; Corbane, C.; Szabo, F. Recent Developments in Some Long-Term Drought Drivers. *Climate* **2022**, *10*, 31. [CrossRef]
31. Chang, C.-P.; Wang, Z.; Hendon, H. The Asian Winter Monsoon. In *The Asian Monsoon*; Wang, B., Ed.; Springer: Berlin/Heidelberg, Germany, 2006; pp. 89–127. [CrossRef]
32. Babkin, V.I. Atmospheric Precipitation of the Earth. In *Encyclopedia of Life Support Systems (EOLSS)*; Wikimedia Foundation, Inc.: San Francisco, CA, USA, 2009; Volume II, pp. 20–47.
33. Tandon, S.K.; Sinha, R. Geology of Large River Systems. *Large Rivers Geomorphol. Manag.* **2022**, *2*, 7–41. [CrossRef]
34. Sun, C.; Wang, S.; Chen, W. Hydrochemical Characteristics and the Relationship between Surface and Groundwater in a Typical 'Mountain–Oasis' Ecosystem in Central Asia. *Sustainability* **2022**, *14*, 7453. [CrossRef]
35. Pritchard, H.D. Asia's shrinking glaciers protect large populations from drought stress. *Nature* **2019**, *569*, 649–654. [CrossRef]
36. Chen, F.; Wang, Q.; Yang, S.; Zhang, Q.; Liu, X.; Chen, J.; Carranza, E.J.M. Space-time distribution of manganese ore deposits along the southern margin of the South China Block, in the context of Palaeo-Tethyan evolution. *Int. Geol. Rev.* **2018**, *60*, 72–86. [CrossRef]
37. Sophia, S.G.G.; Sharmila, V.C.; Suchitra, S.; Muthu, T.S.; Pavithra, B. Water management using genetic algorithm-based machine learning. *Soft Comput.* **2020**, *24*, 17153–17165. [CrossRef]
38. Lee, E.; Jayakumar, R.; Shrestha, S.; Han, Z. Assessment of transboundary aquifer resources in Asia: Status and progress towards sustainable groundwater management. *J. Hydrol. Reg. Stud.* **2018**, *20*, 103–115. [CrossRef]
39. Indika, S.; Wei, Y.; Cooray, T.; Ritigala, T.; Jinadasa, K.B.S.N.; Weragoda, S.K.; Weerasooriya, R. Groundwater-Based Drinking Water Supply in Sri Lanka: Status and Perspectives. *Water* **2022**, *14*, 1428. [CrossRef]

40. World Bank Group. Water for Prosperity and Development: Risks and Opportunities for the Gulf Cooperation Council Countries; World Bank: 2017. Available online: https://documents.worldbank.org/en/publication/documents-reports/documentdetail/920341516598399529/water-for-prosperity-and-development-risks-and-opportunities-for-the-gulf-cooperation-council-countries (accessed on 14 January 2023).
41. Rambo, K.A.; Warsinger, D.M.; Shanbhogue, S.J.; Lienhard, V.J.H.; Ghoniem, A.F. Water-Energy Nexus in Saudi Arabia. *Energy Procedia* **2017**, *105*, 3837–3843. [CrossRef]
42. Siddiqi, S.A.; Al-Mamun, A.; Baawain, M.S.; Sana, A. Groundwater contamination in the Gulf Cooperation Council (GCC) countries: A review. *Environ. Sci. Pollut. Res.* **2021**, *28*, 21023–21044. [CrossRef] [PubMed]
43. FAO. The State of Food Security and Nutrition in the World: Building Climate Resilience for Food Security and Nutrition. 2018. Available online: https://www.wfp.org/publications/2018-state-food-security-and-nutrition-world-sofi-report (accessed on 14 January 2023).
44. FAO. Regional Overview of Food Insecurity-Near East and North Africa: Strengthening Regional Collaboration to Build Resilience for Food Security and Nutrition. 2015. Available online: https://www.fao.org/documents/card/fr/c/b715647e-a958-4b88-87fc-9d1c3364b161/ (accessed on 14 January 2023).
45. Jägerskog, A.; Barghouti, S. Water-Energy Nexus in the GCC Countries. Available online: https://documents.worldbank.org/en/publication/documentsreports/documentdetail/099355009132215715/p1768640ebe4770180b3970bccc84ae2926 (accessed on 14 January 2023).
46. Al-Zubari, W.; Al-Turbak, A.; Zahid, W.; Al-Ruwis, K.; Al-Tkhais, A.; Al-Muataz, I.; Abdelwahab, A.; Murad, A.; Al-Harbi, M.; Al-Sulaymani, Z. An overview of the GCC Unified Water Strategy (2016–2035). *Desalination Water Treat.* **2017**, *81*, 1–18. [CrossRef]
47. Bindra, S.P.; Abulifa, S.; Hamid, A.; Reiani, H.S.A.; Abdalla, K. Assessment of Impacts on Ground Water Resources in Libya and Vulnerability to Climate Change. *Sci. Bull. Petru Maior Univ. Tîrgu Mureş* **2013**, *10*, 63–69.
48. Villholth, K.; Altchenko, Y. Is Groundwater the Key to Increasing Food Security in Sub Saharan Africa? CGIAR 2016. Available online: https://wle.cgiar.org/thrive/2016/04/23/groundwater-key-increasing-food-security-sub-saharan-africa (accessed on 21 December 2022).
49. Reda, A.; Eissa, M.; El Shamy, I.; Dotsika, E.; Saied, M.; Mosaad, S. Using Geochemical and Environmental Isotopic Tracers to Evaluate Groundwater Recharge and Mineralization Processes in Qena Basin, Eastern Nile Valley, Egypt. *Appl. Sci.* **2022**, *12*, 8391. [CrossRef]
50. Pierre, D.; Aurouet, A.; Essayan, V.; Eberschweiler, C. Integrated Water Resources Management of the Iullemeden-Taoudeni/Tanezrouft Aquifer Systems along with the Niger River. In Proceedings of the 25th Annual International Conference on Soil, Water, Energy, and Air, San Diego, CA, USA, 23–26 March 2015; p. 33.
51. Bäumle, R.; Himmelsbach, T.; Noell, U. Hydrogeology and geochemistry of a tectonically controlled, deep-seated and semi-fossil aquifer in the Zambezi Region (Namibia). *Hydrogeol. J.* **2019**, *27*, 885–914. [CrossRef]
52. Owor, M.; Okullo, J.; Fallas, H.; MacDonald, A.M.; Taylor, R.; MacAllister, D.J. Permeability of the weathered bedrock aquifers in Uganda: Evidence from a large pumping-test dataset and its implications for rural water supply. *Hydrogeol. J.* **2022**, *30*, 2223–2235. [CrossRef]
53. Broster, B.E.; Dickinson, P.J. Late Wisconsinan and Holocene development of Grand Lake Meadows area and southern reaches of the Saint John River Valley, New Brunswick, Canada. *Atl. Geol.* **2015**, *51*, 206–220. [CrossRef]
54. Goes, B.J.M. Review: Assessment of the aquifers in South Sudan with a focus on Lakes State. *Hydrogeol. J.* **2022**, *30*, 1035–1053. [CrossRef]
55. MacDonald, A.; Davies, J.; Calow, R. African hydrogeology and rural water supply. In *Applied Groundwater Studies in Africa*; CRC Press: Boca Raton, FL, USA, 2008; pp. 137–158. [CrossRef]
56. Zammouri, M.; Siegfried, T.; El-Fahem, T.; Kriâa, S.; Kinzelbach, W. Salinization of groundwater in the Nefzawa oases region, Tunisia: Results of a regional-scale hydrogeologic approach. *Hydrogeol. J.* **2007**, *15*, 1357–1375. [CrossRef]
57. Abd-Elaty, I.; Abd-Elmoneem, S.M.; Abdelaal, G.M.; Vrána, J.; Vranayová, Z.; Abd-Elhamid, H.F. Groundwater Quality Modeling and Mitigation from Wastewater Used in Irrigation, a Case Study of the Nile Delta Aquifer in Egypt. *Int. J. Environ. Res. Public Health* **2022**, *19*, 14929. [CrossRef] [PubMed]
58. Van der Gun, J. Large Aquifer Systems Around the World. The Groundwater Project. 2022, pp. 1–124. Available online: https://aquadoc.typepad.com/files/large-aquifer-systems-around-the-world.pdf (accessed on 30 November 2022). [CrossRef]
59. Re, V.; Zuppi, G.M. Influence of precipitation and deep saline groundwater on the hydrological systems of Mediterranean coastal plains: A general overview. *Hydrol. Sci. J.* **2011**, *56*, 966–980. [CrossRef]
60. International Association of Hydrogeologists, Food Security and Groundwater. 2015, pp. 1–6. Available online: https://iah.org/wp-content/uploads/2015/11/IAH-Food-Security-Groundwater-Nov-2015.pdf (accessed on 21 December 2022).
61. Carvalho, L.M.V. Assessing precipitation trends in the Americas with historical data: A review. *Wiley Interdiscip. Rev. Clim. Chang.* **2020**, *11*, e627. [CrossRef]
62. Xueke, J. Recharge Estimation from Return Flow on Irrigated Land in the Assiniboine Delta Aquifer. Master's Thesis, University of Manitoba, Winnipeg, MB, Canada, 2022.
63. Bhatti, A.Z.; Farooque, A.A.; Li, Q.; Abbas, F.; Acharya, B. Spatial Distribution and Sustainability Implications of the Canadian Groundwater Resources under Changing Climate. *Sustainability* **2021**, *13*, 9778. [CrossRef]
64. Barlow, P.M.; Reichard, E.G. Saltwater intrusion in coastal regions of North America. *Hydrogeol. J.* **2010**, *18*, 247–260. [CrossRef]

65. Reynolds, R.J.; Heisig, P.M.; Linsey, K.S. *Hydrogeology of Aquifers within the Fairport-Lyons Channel System and Adjacent Areas in Wayne, Ontario, and Seneca Counties, New York*; Scientific Investigations Report 2021-5086; U.S. Geological Survey: Reston, VA, USA, 2022. [CrossRef]
66. Nikolaou, G.; Neocleous, D.; Christophi, C.; Heracleous, T.; Markou, M. Irrigation Groundwater Quality Characteristics: A Case Study of Cyprus. *Atmosphere* **2020**, *11*, 302. [CrossRef]
67. Warziniack, T.; Arabi, M.; Brown, T.C.; Froemke, P.; Ghosh, R.; Rasmussen, S.; Swartzentruber, R. Projections of Freshwater Use in the United States Under Climate Change. *Earth's Futur.* **2022**, *10*, e2021EF002222. [CrossRef]
68. Villada-Canela, M.; Muñoz-Pizza, D.M.; García-Searcy, V.; Camacho-López, R.; Daesslé, L.W.; Mendoza-Espinosa, L. Public Participation for Integrated Groundwater Management: The Case of Maneadero Valley, Baja California, Mexico. *Water* **2021**, *13*, 2326. [CrossRef]
69. Carrasco-Núñez, G.; Díaz-Castellón, R.; Siebert, L.; Hubbard, B.; Sheridan, M.F.; Rodríguez, S.R. Multiple edifice-collapse events in the Eastern Mexican Volcanic Belt: The role of sloping substrate and implications for hazard assessment. *J. Volcanol. Geotherm. Res.* **2006**, *158*, 151–176. [CrossRef]
70. Khajvand, M.; Mostafazadeh, A.K.; Drogui, P.; Tyagi, R.D. Management of greywater: Environmental impact, treatment, resource recovery, water recycling, and decentralization. *Water Sci. Technol.* **2022**, *86*, 909–937. [CrossRef] [PubMed]
71. Naz, T.; Iqbal, M.M.; Akhtar, J.; Saqib, M.; Ali, M.; Zafar, M.I.; Dell, B.; Datta, R.; Ansari, M.J.; Danish, S.; et al. Carbohydrate Partitioning, Growth and Ionic Compartmentalisation of Wheat Grown under Boron Toxic and Salt Degraded Land. *Agronomy* **2022**, *12*, 740. [CrossRef]
72. Goswami, P.; Mathur, J.; Srivastava, N. Silica nanoparticles as novel sustainable approach for plant growth and crop protection. *Heliyon* **2022**, *8*, e09908. [CrossRef] [PubMed]
73. Khan, M.M.; Siddiqi, S.A.; Farooque, A.A.; Iqbal, Q.; Shahid, S.A.; Akram, M.T.; Rahman, S.; Al-Busaidi, W.; Khan, I. Towards Sustainable Application of Wastewater in Agriculture: A Review on Reusability and Risk Assessment. *Agronomy* **2022**, *12*, 1397. [CrossRef]
74. Selmane, T.; Dougha, M.; Hasbaia, M.; Ferhati, A.; Redjem, A. Hydrogeochemical processes and multivariate analysis for groundwater quality in the arid Maadher region of Hodna, northern Algeria. *Acta Geochim.* **2022**, *41*, 893–909. [CrossRef]
75. Fathelrahman, E.; Gheblawi, M.; Muhammad, S.; Dunn, E.; Ii, J.C.A.; Green, T.R. Optimum Returns from Greenhouse Vegetables under Water Quality and Risk Constraints in the United Arab Emirates. *Sustainability* **2017**, *9*, 719. [CrossRef]
76. Basak, N.; Rai, A.K.; Sundha, P.; Meena, R.L.; Bedwal, S.; Yadav, R.K.; Sharma, P.C. Assessing soil quality for rehabilitation of salt-affected agroecosystem: A comprehensive review. *Front. Environ. Sci.* **2022**, *10*, 935785. [CrossRef]
77. Gedik, S.; Mugan-Ertugral, S. The effects of marine tourism on water pollution. *Fresenius Env. Bull.* **2019**, *28*, 863–866.
78. Landschoot, P.J.; Spargo, J.; McGraw, B.A. A survey of turfgrass irrigation water quality in Pennsylvania. *Crop. Forage Turfgrass Manag.* **2022**, *8*, e20157. [CrossRef]
79. Guo, Y.; Li, P.; He, X.; Wang, L. Groundwater Quality in and Around a Landfill in Northwest China: Characteristic Pollutant Identification, Health Risk Assessment, and Controlling Factor Analysis. *Expo. Health* **2022**, *14*, 885–901. [CrossRef]
80. Treter, R.J.; Carvalho, I.R.; Hutra, D.J.; Loro, M.V.; Cavinatto, M.; Lautenchleger, F.; Sfalcin, I.C. Symptoms and interrelationships of macro and micronutrients available for soybean. *Agron. Sci. Biotechnol.* **2021**, *8*, 1–15. [CrossRef]
81. Machado, R.M.A.; Serralheiro, R.P. Soil Salinity: Effect on Vegetable Crop Growth. Management Practices to Prevent and Mitigate Soil Salinization. *Horticulturae* **2017**, *3*, 30. [CrossRef]
82. Shamsabad, M.R.M.; Esmaeilizadeh, M.; Roosta, H.R.; Dąbrowski, P.; Telesiński, A.; Kalaji, H.M. Supplemental light application can improve the growth and development of strawberry plants under salinity and alkalinity stress conditions. *Sci. Rep.* **2022**, *12*, 9272. [CrossRef]
83. Sublett, W.L.; Barickman, T.C.; Sams, C.E. Effects of Elevated Temperature and Potassium on Biomass and Quality of Dark Red 'Lollo Rosso' Lettuce. *Horticulturae* **2018**, *4*, 11. [CrossRef]
84. Struckmeyer, W.F.W.; Esther, B. Effects of Chloride and Sulfate Ions on the Growth, Leaf Burn, Composition and Anatomical Structure of Tobacco (*Nicotiana tabacum* L.). *Plant Physiol.* **2022**, *33*, 133–139.
85. Shahid, S.A.; Zaman, M.; Heng, L. Introduction to Soil Salinity, Sodicity and Diagnostics Techniques. In *Guideline for Salinity Assessment, Mitigation and Adaptation Using Nuclear and Related Techniques*; Spinger: Berlin/Heidelberg, Germany, 2018; pp. 1–42. [CrossRef]
86. Alaoui, I.; Serbouti, S.; Ahmed, H.; Mansouri, I.; El Kamari, F.; Taroq, A.; Ousaaid, D.; Squalli, W.; Farah, A. The Mechanisms of Absorption and Nutrients Transport in Plants: A Review. *Trop. J. Nat. Prod. Res.* **2022**, *6*, 8–14. [CrossRef]
87. Blanchard, C.; Wells, D.; Pickens, J.; Blersch, D. Effect of pH on Cucumber Growth and Nutrient Availability in a Decoupled Aquaponic System with Minimal Solids Removal. *Horticulturae* **2020**, *6*, 10. [CrossRef]
88. Douglas, C. Water Quality: pH and Alkalinity, Univ. Massachusetts. 1995; pp. 50–51. Available online: https://ag.umass.edu/greenhouse-floriculture/fact-sheets/water-quality-ph-alkalinity (accessed on 21 December 2022).
89. Mathers, H.M.; Lowe, S.B.; Scagel, C.; Struve, D.K.; Case, L.T. Abiotic Factors Influencing Root Growth of the window of marketability of the Woody Nursery Plants in Containers. *Horttechnology* **2007**, *17*, 151–162. [CrossRef]
90. Magdoff, F.; Williams, C. *Creating an Ecological Society: Toward a Revolutionary Transformation*; NYU Press: New York, NY, USA, 2017; pp. 1–373.

91. Ghori, N.-H.; Ghori, T.; Hayat, M.Q.; Imadi, S.R.; Gul, A.; Altay, V.; Ozturk, M. Heavy metal stress and responses in plants. *Int. J. Environ. Sci. Technol.* **2019**, *16*, 1807–1828. [CrossRef]
92. Olivares, B.O.; Calero, J.; Rey, J.C.; Lobo, D.; Landa, B.B.; Gómez, J.A. Correlation of banana productivity levels and soil morphological properties using regularized optimal scaling regression. *Catena* **2022**, *208*, 105718. [CrossRef]
93. Olivares, B.O.; Rey, J.C.; Perichi, G.; Lobo, D. Relationship of Microbial Activity with Soil Properties in Banana Plantations in Venezuela. *Sustainability* **2022**, *14*, 13531. [CrossRef]
94. Olivares, B.O.; Vega, A.; Calderón, M.A.R.; Rey, J.C.; Lobo, D.; Gómez, J.A.; Landa, B.B. Identification of Soil Properties Associated with the Incidence of Banana Wilt Using Supervised Methods. *Plants* **2022**, *11*, 2070. [CrossRef] [PubMed]
95. Campos, B.O.O.; Paredes, F.; Rey, J.C.; Lobo, D.; Galvis-Causil, S. The relationship between the normalized difference vegetation index, rainfall, and potential evapotranspiration in a banana plantation of Venezuela. *Soc. Psychol. Soc.* **2021**, *12*, 58–64. [CrossRef]
96. Al-taai, S.H.H. Environmental pollution "causes-types-effects" Environmental Pollution "Causes-Types-Effects". *AIP Conf. Proc.* **2022**, *2398*, 040023.
97. Lerner, D.N.; Harris, B. The relationship between land use and groundwater resources and quality. *Land Use Policy* **2009**, *26*, S265–S273. [CrossRef]
98. Yadav, M.K.; Gupta, A.K.; Ghosal, P.S.; Mukherjee, A. Effect of coexisting ions on adsorptive removal of arsenate by Mg-Fe-(CO_3) LDH: Multi-component adsorption and ANN-based multivariate modeling. *J. Environ. Sci. Health Toxic/Hazardous Subst. Environ. Eng.* **2021**, *56*, 572–584. [CrossRef]
99. Jorgelina, M.; Mimi, T.; David, F.; Curtis, E.; Jennie, G. Pseudokirchneriella subcapitata, Ceriodaphnia dubia and Rainbow Trout Responses to Uranium Exposure in Combination with Metals, Nutrients and Total Dissolved Solids mixtures Using Site Water Collected from Two Creeks Located in the Yukon. *Adv. Environ. Stud.* **2022**, *6*, 455–466. [CrossRef]
100. Química, D.; Tecnológica, Q.; Cristina, S.; Marques, R.; Doutora, P.; Paula, A. Different Approaches to the Development and Use of Carbon Materials for Water Treatment Purposes. Ph.D. Thesis, Universidade de Lisboa, Lisboa, Portugal, 2017; pp. 1–369.
101. Nigam, A.; Priya, S.; Bajpai, P.; Kumar, S. Cytogenomics of hexavalent chromium (Cr^{6+}) exposed cells: A comprehensive review. *Indian J. Med. Res.* **2014**, *139*, 349–370.
102. Omer, N.H. Water Quality Parameters. *Intech* **2019**, *18*, 1–34. Available online: https://www.intechopen.com/chapters/69568 (accessed on 10 November 2022).
103. Metcalfe, C.; Bayen, S.; Desrosiers, M.; Muñoz, G.; Sauvé, S.; Yargeau, V. An introduction to the sources, fate, occurrence and effects of endocrine disrupting chemicals released into the environment. *Environ. Res.* **2022**, *207*, 112658. [CrossRef]
104. Li, P.; Karunanidhi, D.; Subramani, T.; Srinivasamoorthy, K. Sources and Consequences of Groundwater Contamination. *Arch. Environ. Contam. Toxicol.* **2021**, *80*, 1–10. [CrossRef] [PubMed]
105. Ahammad, S.Z.; Graham, D.W.; Dolfing, J. Wastewater treatment: Biological. In *Managing Water Resources and Hydrological Systems*; CRC Press: Boca Raton, FL, USA, 2020; pp. 561–576. [CrossRef]
106. Vahabian, M.; Hassanzadeh, Y.; Marofi, S. Assessment of landfill leachate in semi-arid climate and its impact on the groundwater quality case study: Hamedan, Iran. *Environ. Monit. Assess.* **2019**, *191*, 109. [CrossRef]
107. Wijekoon, P.; Koliyabandara, P.A.; Cooray, A.T.; Lam, S.S.; Athapattu, B.C.; Vithanage, M. Progress and prospects in mitigation of landfill leachate pollution: Risk, pollution potential, treatment and challenges. *J. Hazard. Mater.* **2022**, *421*, 126627. [CrossRef] [PubMed]
108. Koohsaryan, E.; Anbia, M.; Maghsoodlu, M. Application of zeolites as non-phosphate detergent builders: A review. *Biochem. Pharmacol.* **2020**, *8*, 104287. [CrossRef]
109. Chan, Y.J.; Chong, M.F.; Law, C.L.; Hassell, D. A review on anaerobic–aerobic treatment of industrial and municipal wastewater. *Chem. Eng. J.* **2009**, *155*, 1–18. [CrossRef]
110. Cheng, M.; Zeng, G.; Huang, D.; Lai, C.; Xu, P.; Zhang, C.; Liu, Y. Hydroxyl radicals based advanced oxidation processes (AOPs) for remediation of soils contaminated with organic compounds: A review. *Chem. Eng. J.* **2015**, *284*, 582–598. [CrossRef]
111. Cabral, J.P.S. Water Microbiology. Bacterial Pathogens and Water. *Int. J. Environ. Res. Public Health* **2010**, *7*, 3657–3703. [CrossRef]
112. Kim, H.S.; Devarenne, T.P.; Han, A. Microfluidic systems for microalgal biotechnology: A review. *Algal Res.* **2018**, *30*, 149–161. [CrossRef]
113. Zarei, M. Portable biosensing devices for point-of-care diagnostics: Recent developments and applications. *TrAC Trends Anal. Chem.* **2017**, *91*, 26–41. [CrossRef]
114. Koroša, A.; Mali, N. Control of organic contaminants in groundwater by passive sampling and multivariate statistical analysis. *J. Environ. Manag.* **2022**, *318*, 115440. [CrossRef]
115. Gajic, I.; Kabic, J.; Kekic, D.; Jovicevic, M.; Milenkovic, M.; Culafic, D.M.; Trudic, A.; Ranin, L.; Opavski, N. Antimicrobial Susceptibility Testing: A Comprehensive Review of Currently Used Methods. *Antibiotics* **2022**, *11*, 427. [CrossRef] [PubMed]
116. Deshmukh, R.A.; Joshi, K.; Bhand, S.; Roy, U. Recent developments in detection and enumeration of waterborne bacteria: A retrospective minireview. *Microbiologyopen* **2016**, *5*, 901–922. [CrossRef] [PubMed]
117. Siddiqua, A.; Hahladakis, J.N.; A Al-Attiya, W.A.K. An overview of the environmental pollution and health effects associated with waste landfilling and open dumping. *Environ. Sci. Pollut. Res.* **2022**, *29*, 58514–58536. [CrossRef]
118. Strugała-Wilczek, A.; Kapusta, K. Migration of Co, Cd, Cu, Pb to the groundwater in the area of underground coal gasification experiment in a shallow coal seam in the experimental mine 'Barbara' in Poland. *Fuel* **2022**, *317*, 122831. [CrossRef]

119. Hou, S.; Xu, J.; Yao, L. Integrated environmental policy instruments driven river water pollution management decision system. *Socio-Economic Plan. Sci.* **2020**, *75*, 100977. [CrossRef]
120. Mackie, C.; Lackey, R.; Levison, J.; Rodrigues, L. Groundwater as a source and pathway for road salt contamination of surface water in the Lake Ontario Basin: A review. *J. Great Lakes Res.* **2022**, *48*, 24–36. [CrossRef]
121. Uthayashangar, S.; Nanthakumaran, A.; Devaisy, S. Status of the saltwater intrusion in Jaffna, Sri Lanka. *Ceylon J. Sci.* **2019**, *48*, 235. [CrossRef]
122. Abdalla, F.; Khalil, R. Potential effects of groundwater and surface water contamination in an urban area, Qus City, Upper Egypt. *J. Afr. Earth Sci.* **2018**, *141*, 164–178. [CrossRef]
123. Li, X.; Zhang, L.; Yang, Z.; He, Z.; Wang, P.; Yan, Y.; Ran, J. Hydrophobic modified activated carbon using PDMS for the adsorption of VOCs in humid condition. *Sep. Purif. Technol.* **2020**, *239*, 116517. [CrossRef]
124. Norfazilah, W.I.; Mokhtar, S.U. Various Methods for Removal, Treatment, and Detection of Emerging Water Contaminants. In *Emerging Contaminants*; IntechOpen: London, UK, 2020; pp. 1–28.
125. Kumar, R.; Qureshi, M.; Vishwakarma, D.K.; Al-Ansari, N.; Kuriqi, A.; Elbeltagi, A.; Saraswat, A. Case Studies in Chemical and Environmental Engineering Case Report A review on emerging water contaminants and the application of sustainable removal technologies. *Case Stud. Chem. Environ. Eng.* **2022**, *6*, 100219. [CrossRef]
126. Bera, S.P.; Godhaniya, M.; Kothari, C. Emerging and advanced membrane technology for wastewater treatment: A review. *J. Basic Microbiol.* **2021**, *62*, 245–259. [CrossRef]
127. Meshksar, M.; Roostaee, T.; Rahimpour, M.R. *Membrane Technology for Brewery Wastewater Treatment*; Elsevier Inc.: Amsterdam, The Netherlands, 2020; pp. 289–303. [CrossRef]
128. Banerjee, P.; Das, R.; Das, P. Membrane Technology. In *Carbon Nanotubes for Clean Water*; Springer: Cham, Switzerland, 2018; pp. 127–150.
129. Hokpande, S.R.; Kulkarni, S.J.; Kaware, D.J.P. A Review on Research on Application of Trickling Filters in Removal of Various Pollutants from Effluent. *Int. J. Eng. Sci. Res. Technol.* **2014**, *3*, 359–365.
130. Sodhi, V.; Bansal, A.; Jha, M.K. Excess sludge disruption and pollutant removal from tannery effluent by upgraded activated sludge system. *Bioresour. Technol.* **2018**, *263*, 613–624. [CrossRef]
131. Santo, C.E.; Vilar, V.J.; Bhatnagar, A.; Kumar, E.; Botelho, C.M.; Boaventura, R.A.; Santo, C.E.; Vilar, V.J.; Bhatnagar, A.; Kumar, E.; et al. Biological treatment by activated sludge of petroleum refinery wastewaters. *Desalination Water Treat.* **2013**, *51*, 6641–6654. [CrossRef]
132. Goli, A.; Shamiri, A.; Khosroyar, S.; Talaiekhozani, A.; Sanaye, R. A Review on Different Aerobic and Anaerobic Treatment Methods in Dairy Industry Wastewater. *J. Environ. Treat. Tech.* **2019**, *7*, 113–141.
133. Sehar, S.; Naz, I. Role of the Biofilms in Wastewater Treatment. In *Microbial Biofilms-Importance and Applications*; IntechOpen: London, UK, 2016. [CrossRef]
134. Aluko, O.O.; Sridhar, M.K. Evaluation of leachate treatment by trickling filter and sequencing batch reactor processes in Ibadan, Nigeria. *Waste Manag. Res.* **2013**, *31*, 700–705. [CrossRef]
135. Rehman, A.; Anees, M.; Sehar, S.; Alhewairini, S.S.; Saroj, D.P.; Ahmed, S. Simulated Modelling, Design, and Performance Evaluation of a Pilot-Scale Trickling Filter System for Removal of Carbonaceous Pollutants from Domestic Wastewater. *Water* **2021**, *13*, 3210. [CrossRef]
136. Zhu, S.; Wang, D. Photocatalysis: Basic Principles, Diverse Forms of Implementations and Emerging Scientific Opportunities. *Adv. Energy Mater.* **2017**, *7*, 1700841. [CrossRef]
137. Wu, J.J.; Wu, C.-C.; Ma, H.-W.; Chang, C.-C. Treatment of landfill leachate by ozone-based advanced oxidation processes. *Chemosphere* **2004**, *54*, 997–1003. [CrossRef] [PubMed]
138. Misra, N. The contribution of non-thermal and advanced oxidation technologies towards dissipation of pesticide residues. *Trends Food Sci. Technol.* **2017**, *45*, 229–244. [CrossRef]