An Exploration of the Application of Desalination in Disaster Relief

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A Senior Thesis submitted in partial fulfillment
of the requirements for graduation
in the Honors Program
Liberty University
Spring 2023

Acceptance of Senior Honors Thesis

This Senior Honors Thesis is accepted in partial
fulfillment of the requirements for graduation from the
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Acknowledgements

I would first like to express my deepest gratitude to God for His providence during my training to become a Champion for Christ at Liberty University. I am grateful for my parents, brother, and friends, who kept my flame burning throughout this research and my academic journey. I thank Dr. Kalehiwot Nega Manahiloh, my thesis chair, for his guidance and assistance with this research. I would also like to thank each of my professors at Liberty University for their valuable guidance and lessons in completing this thesis. Last, but not least, I thank the Honors Program for facilitating this process and affording me the opportunity to work on this thesis.

Table of Figures

Figure 1 - Stages of MSF distillation process (modified from Shatilla, 2020) 2

Figure 2 - This figure shows the MED distillation process (modified from Shatilla, 2020) 2

Figure 3 - The process of vapor compression desalination (modified from Shatilla, 2020). 2

Figure 4 - Basic illustration of a solar still distillation system (modifed from Boden & Subban, 2018) 2

Figure 5 - Diagram of reverse osmosis showing saline flow through a membrane (modified from Thomson et al., 2001). 2

Figure 6 - Schematic of ion exchange occurring within an electrodialysis desalination system (modified from Shatilla, 2020). 2

Figure 7 - Solar still being tested outside (Samee, Mirza, Majeed, & Ahmad, 2007) 2

Abstract

This paper aims to explore the application of small-scale desalination systems to provide clean water in the wake of marine natural disasters. A lack of clean water is a devastating impact of many natural disasters. Desalination technologies, both thermal and membrane, show potential for being scaled down and self-powered by renewable energy. Desalination can transform ocean water and contaminated drinking water with a high salt content into drinkable, usable water. While these techniques are not perfected, and the solution to a need for clean water is multifaceted, desalination shows potential. Through further research and ever-advancing technology, small-scale desalination could develop into a life-saving solution for those in need of clean water.

An Exploration of the Application of Desalination in Disaster Relief

Chapter 1: Introduction

1.1 Introduction

With about seventy-one percent of the earth's surface being covered by water, one would have a hard time believing that humanity is in the midst of a water crisis. However, when it is considered that only about three percent of earth's water is freshwater, this becomes more believable (Ayoub, 1995). Even though water is in abundance, this does not mean it is clean, usable, or accessible for all people. In fact, in some instances, an area will have clean water access, but that will be disrupted by a natural disaster. With most disasters being water-related, it is no wonder that the occurrence of a natural disaster oftentimes threatens people's clean water access (Masoud, 2020). This is especially true in the case of marine natural disasters such as tsunamis, floods, or hurricanes. These can all have disastrous effects on people's livelihoods and destroy clean water supplies by contaminating freshwater with ocean water and making it unusable for drinking, agriculture, and sanitation. After a marine natural disaster occurs, those affected are advised to drink and use treated, bottled, or boiled water due to the possible contamination of water sources. Often, attaining this clean water is difficult or nearly impossible, especially in an underdeveloped country where resources may be limited. Therefore, developing approaches to providing clean water to those in need in the wake of a marine disaster is of paramount importance. If effective strategies for providing people with clean, safe water can be provided, the disastrous immediate and long-term impacts of natural disasters can be mitigated.

Currently, one method of clean water provision that is used globally in coastal areas is the process of desalination (Victoria State Government , 2019). This is the process by which salt water is converted to fresh water (Water.org, 2023). If this process can be streamlined, it holds the potential to be a way in which ocean water can be converted to freshwater after marine natural disasters. Integration of renewable energy into desalination systems holds promise for increasing the efficiency and feasibility of the process (Wimalawansa, 2013). If used in conjunction with renewable energy, desalination methods can be a strategic approach to providing clean water access. To assess how desalination systems that integrate renewable energy can be applied to combatting the lack of clean water access after marine natural disasters, an exploration of current research will be carried out. Overviewing the water crisis to establish a general understanding of the impact of water scarcity will be followed by an explanation of desalination methods and current systems. Further, the use of renewable energies in desalination processes in the current day will be discussed to assess how renewables can improve desalination. To then address the question of how such systems can assist in natural disaster relief, current methods will be assessed, and the potential for integration of desalination into these responses will be explored.

1.2 Objective and Scope

This paper presents an explanation of the water crisis and desalination to establish a framework of understanding. It then aims to assess the current research to determine the feasibility of the application of renewable energy-integrated desalination systems to combat the impacts of marine natural disasters.

1.3 Thesis Organization

Chapter 1 – Introduces the water crisis, and the impact marine disasters on clean water access. Desalination is briefly explained as a possible solution for providing clean water, as well as renewable energy integration into desalination systems.

Chapter 2 – Reviews past research covering the topics of the water crisis, desalination, and the integration of renewable energy into desalination systems. In addition, literature regarding current desalination systems in use around the world is covered.

***Chapter 3* –** Builds upon the reviewed literature, discusses desalinations potential use in providing clean water for marine disaster relief.

Chapter 4 – Concludes the literature review, and discussion on desalination. Looks at how future research could be developed.

Chapter 2: Literature Review

2.1 The Water Crisis

The world today faces a global issue with severe impacts: the water crisis. Providing access to clean water has been deemed one of the 14 Grand Challenges for Engineering in the 21st Century (Water.org, 2023). A large amount of discussion has transpired surrounding how the water crisis should be combatted, and many solutions have been weighed (Water.org, 2023). Not having access to clean water, whether it be a momentary situation or a perpetual state, has egregious impacts on the lives of human beings (Water.org, 2023). Thus, the scientific and engineering community seeks to develop new ways to provide and sustain clean water access globally (United Nations, 2023). Beginning in the 1700s to 1800s, the increase in urbanization resulting from the Industrial Revolution resulted in the necessity of clean water being emphasized. Following this, in the 1800s, the first water shortages appear in historical records (IDE Technologies , 2018). Public water systems in the years following developed in many countries. But as these systems developed, the lack of clean water became an even more noticeable and recognized problem (Reid, 2021). Today, 1 in 10 people, 771 million, don't have access to safe water. Every year almost 1 million people pass away from a sickness that could be made less impactful with clean water access (Water.org, 2023). Water scarcity and drought are extremely detrimental to the well-being of much of the global population. Thus, it is a widely discussed topic in the scientific, engineering, and political spheres.

The impacts of a lack of access to clean water are concerning. Generally, the first concern associated with water scarcity is the lack of drinking water (United Nations, 2023). While this is a main concern, it is important to note that a lack of clean water also affects people's agricultural capabilities, their access to sanitation, their everyday household life, and their risk of contracting water-borne diseases (Water.org, 2023). In addition, when a community does not have easy access to clean water, often the responsibility to attain waterfalls is on the women and children of the society (Water.org, 2023). This, in turn, takes the women away from being able to work or care for their families and can remove children from the time at school or playing that is essential to their development (United Nations, 2023). Thus, water and access to it affect education, child development, and family dynamics as well. Finally, a lack of access to clean water is of extensive concern in a sanitary sense since water is necessary for plumbing systems and other forms of everyday hygiene (National Academy of Engineering, 2023).

A lack of fresh water can be a result of various factors: civil unrest, a lack of technology, climate, geographical characteristics, and even the effects of a natural disaster. Geographically speaking, a lack of access to clean water often stems not from a global scarcity of water but from water not being located where it is needed (United Nations, 2023). Further, in some scenarios, water supplies exist but are contaminated by unnatural or naturally occurring pollutants which makes the water unpotable and unconsumable (United Nations, 2023). In some cases, this contamination can occur during or in the wake of a natural disaster (United Nations, 2023). Most natural disasters that occur are water related. Flooding, tsunamis, hurricanes, and droughts are all water-related and make attaining clean water more difficult for those impacted. Natural disasters damage infrastructure that provides sanitation and water and decrease people's ability to practice good hygiene (United Nations, 2023). Thus, trying to develop solutions for water shortages that occur post-natural disasters is deeply relevant to the discussion of combatting the global lack of clean water. Based on a book by the National Research Council Committee on the Ocean's Role in Human Health, it can be said that marine disasters have immediate and long-term ramifications (National Research Council, 1999). Many natural disasters that occur and result in water scarcity for those affected also happen to occur in coastal locations near bodies of saltwater. Thus, much of the freshwater supplies are contaminated with saltwater and are rendered unusable (National Research Council, 1999).

It should also be considered that only about 3 percent of the planet's water is fresh. Therefore, some areas may have water access, but it is saltwater and, thus, cannot be used for agricultural, drinking, or hygienic purposes (National Academy of Engineering, 2023). This abundance of ocean water but lack of fresh water is not a new issue. All throughout history, mankind has made the realization that saltwater, while it holds life, cannot sustain it. If the extensive stores of ocean water can be used as sources of water for consumption and agriculture, then the need for naturally occurring freshwater can be lessened. Therefore, people have developed ways in which to convert saltwater to freshwater (Kyriakarakos & Papadakis, 2021). This process is known as desalination, and there are various methods by which it is carried out.

2.1.1 What is Desalination?

Desalination is the removal of dissolved salts from saline (Petruzzello, 2023). Saline is defined as water that has 1,000 ppm or more dissolved salts. To put this into perspective, ocean water contains roughly 35,000 ppm of dissolved salts. Since this is much greater than the salt content required for water to become classified as saline, it can be noted that desalination is not a process confined to ocean water. This includes seawater, brackish water, highly mineralized groundwater, and municipal wastewater (Petruzzello, 2023). With 39% of the world's population living in coastal areas, there is vast potential for desalination to be used to convert ocean and brackish water to fresh water (United Nations, 2023).

2.1.2 History of Desalination

The idea of desalination is not a new concept by any means. Desalination can be observed in nature in the water cycle when the oceans absorb solar radiation from the sun, causing water to evaporate out of the oceans. Then, the water vapor condenses forming clouds, and eventually, rain falls, giving freshwater (Qiblawey & Banat, 2008). Around the 4th Century BC, Aristotle explained a means by which to take impure water, evaporate it, and then condense it to attain drinkable water (Kalogirou, 2005). It is also recognized that Greek sailors used to boil seawater to attain freshwater during long-distance boat trips. Sailors would boil seawater and then gather the freshwater vapor by using sponges attached to a large vase (Kalogirou, 2005). In another example, Romans utilized clay filters to filter salt out of the water (Victoria State Government , 2019).

During the Renaissance, a scientist by the name of Giovanni Batista Della Porta mentioned seven different methods of desalination in his written works. These methods included solar distillation devices as well as a way to attain fresh water directly from the air (Kalogirou, 2005). Solar distillation was then further developed by scientists such as Lavoisier (1774), and in 1870 the first patent on solar distillation was granted in America. Following this, a Swedish engineer developed the first solar distillation plant in 1872 in Las Salinas, Chile. During the earlier 20th Century, solar distillation continued to develop, and after World War II, the establishment of the Office of Saline Water promoted research of desalination. Around this same time, other countries around the world began experimental work and development of desalination methods (Kalogirou, 2005). Between 1960 and 1975, Greece constructed four solar desalination plants to give fresh water to small island groups. By 2019 roughly 18,000 desalination plants were operational throughout the world and provided potable water for various peoples (Petruzzello, 2023).

Currently, desalination on a large scale to provide consistent drinking water is expensive due to its high energy demand (Petruzzello, 2023). The use of fossil fuels to run desalination plants often diminishes its economic effectiveness (Shatat, Worall, & Riffat, 2013). Even so, it is still used in over 120 countries to provide clean, usable water. As is imaginable, it can provide water for human consumption. But it is not confined to simply producing drinking water; desalinated water is also applied in areas where water is needed for irrigation or industrial and manufacturing applications (Doornbusch, 2021). Roughly half of all desalinated water is produced in the Middle East and Northern Africa. These are both densely populated, arid regions; therefore, clean water is needed but not easily accessible (Petruzzello, 2023). Currently, the most economical way for desalination to be carried out is in large-scale plants (Petruzzello, 2023). For this paper, large-scale desalination plants will be explained but will not be focused on as a means of providing freshwater after marine natural disasters.

2.1.3 Methods of Desalination

The process of desalination can be carried out on a vast array of scales. Most operating plants that provide drinking and usable water today are large-scale due to the higher economic effectiveness of large-scale plants (Petruzzello, 2023). Small-scale desalination systems still use some of the same processes as larger commercialized desalination plants or systems. However, they are used more for small populations and in areas where it is difficult to support an entire large-scale desalination system. Additionally, small-scale desalination has been used throughout history to provide freshwater to small households or even on ships for sailors and passengers, as aforementioned. For the sake of this thesis, more focus will be placed on small-scale desalination systems and methods. This is because the aim is to investigate whether desalination is a viable method of providing freshwater after a marine natural disaster. Thus, it is not necessary to assess if desalination would be a solution for constant freshwater provision but rather a means by which freshwater can be provided until damages can be repaired.

Thermal Desalination

Technologies that involved thermal desalination were the first desalination systems put into commercial use. Using heat to produce a phase change in water and thus separate fresh water from salt-dissolved salts has been an effective technique to attain drinkable water for centuries. As the world has become industrialized and technology continues to grow, this process has been improved upon. There are now various methods by which heat is used to accomplish heat-driven desalination (Boden & Subban , 2018). There are multiple types of thermal desalination, the main types being the following: vapor compression (VC), multi-effect distillation (MED), and multistage flash distillation (MSF) (IDE Technologies , 2018). In addition, solar still distillation, humidification-dehumidification, and freezing are other techniques that are considered thermal desalination.

Multistage-flash distillation sends seawater through a sequence of chambers; this can be seen in Figure 1. In the first chamber, the pressure is suddenly lowered, which makes the water "flash" into steam. Following the saline goes through more consecutive stages. At each stage, the pressure is lower than the previous stage's pressure while the temperature is held constant (Shatilla, 2020).

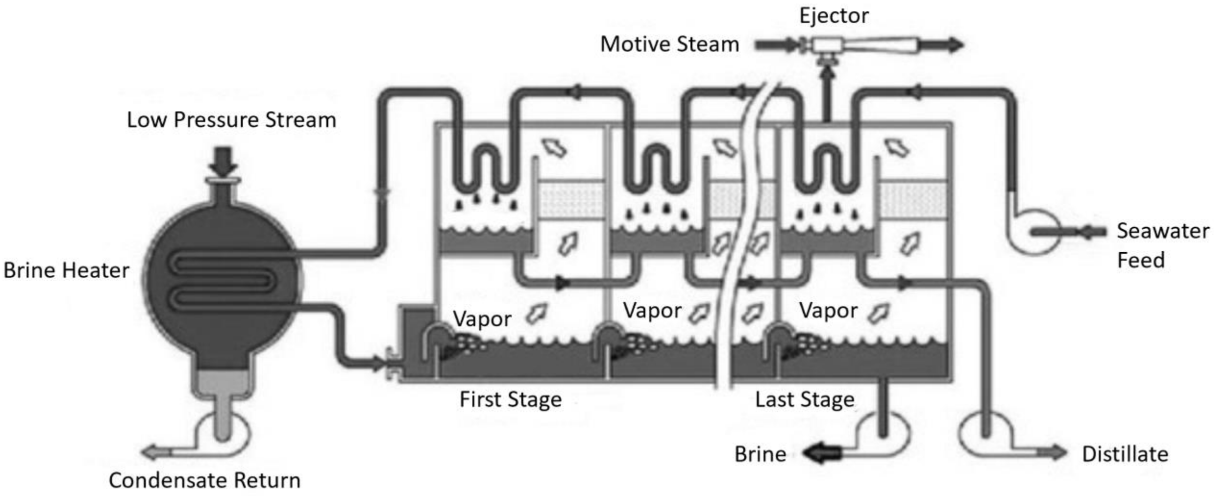

Figure 1 - Stages of MSF distillation process (modified fromShatilla, 2020)

As the saline passes through the stages, it evaporates, leaving salty brine behind. Freshwater is produced by the condensation of the steam, which is cooled via the cool seawater coming into the system. MSF is considered the easiest unit to operate, but it has high capital costs and energy requirements (Shatilla, 2020). Multi-effect distillation uses a similar series of stages with lowering pressures at each stage. However, unlike MSF, evaporation and condensation during MED occur at lower temperatures (Shatilla, 2020). MED systems are comparatively more operationally complex but have lower energy requirements and capital costs (Shatilla, 2020). Figure 2 below shows a multi-effect distillation system.

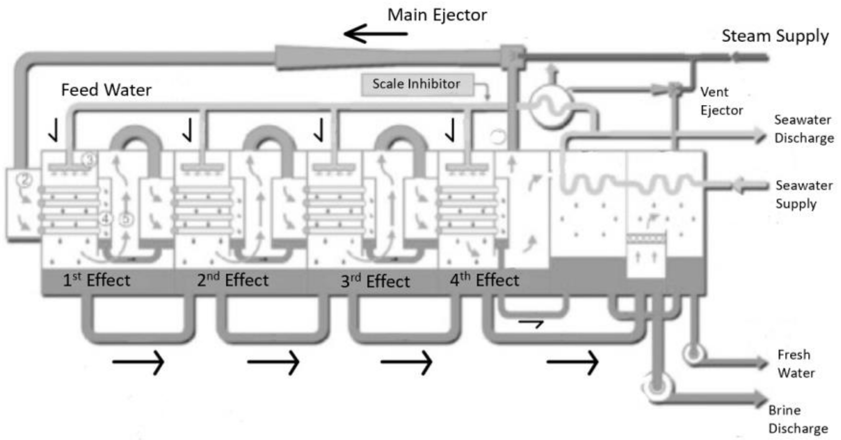

Figure 2 - The MED distillation process (modified from Shatilla, 2020)

Vapor compression distillation, unlike MSF and MED, is typically used in small or medium-scale desalination systems as opposed to in a large-scale plant (Shatilla, 2020). In this system, heat is provided by the compression of vapor as opposed to a boiler. The compressed steam is then used to vaporize the feed water (incoming saltwater). In this system, the main source of energy is usually electricity (Petruzzello, 2023). The process of vapor compression distillation is shown in Figure 3.

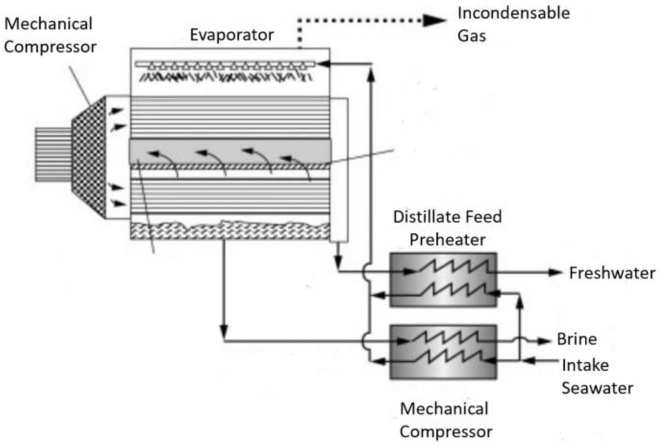

Figure 3 - The process of vapor compression desalination (modified from Shatilla, 2020).

Arguably the simplest method of distillation is solar still distillation. This is considered another type of thermal distillation since it utilizes heat from the sun to evaporate the freshwater out of saline. These systems first documented use was in the 16th Century (Samee et al., 2007). In a solar still, water is heated directly by the sun's rays which evaporates the water, and the vapor then condenses on the glass sill cover (Mohal et al., 2017). The condensed freshwater then drips down into a water channel and can be collected for use (Samee et al., 2007). While this method is very simple and easy to install, it also has generally low productivity and can be impacted by climate. It is a great example, however, of how desalination can be an essentially passive and self-sustaining process when in the right environment (Boden & Subban , 2018). An image showing a basic solar still setup can be seen in Figure 4.

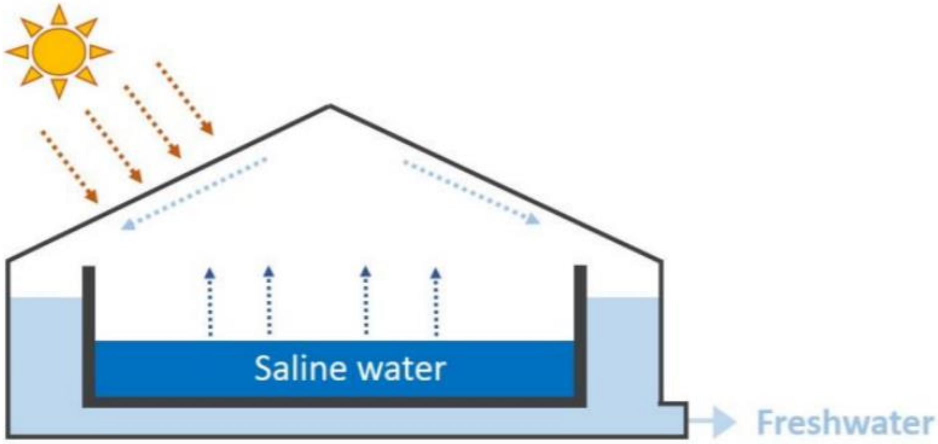

Figure 4 - Basic illustration of a solar still distillation system (modified from Boden & Subban, 2018)

At Jordan University of Science and Technology, a paper was written detailing solar thermal desalination technologies. Solar stills, along with salinity gradient solar ponds, flat plate collectors, and evacuated tube collectors, are defined to be different methods of solar desalination (Qiblawey & Banat, 2008). Another topic discussed in this paper is the potential usability of indirect solar desalination systems. Such systems include two systems; one system collects solar energy, and one system is a standard desalination method (Qiblawey & Banat, 2008).

Membrane Distillation

The other general grouping of desalination methods is membrane desalination. In this method of desalination, salt and minerals are removed from the saline by passing the saline through a series of semi-permeable membranes (Shatilla, 2020). Membrane desalination is fast growing as membrane technology is a highly studied area of science, with vast improvements being made quickly (Que, 2021). As membranes develop, it will allow for membrane desalination to become more efficient and economically feasible. One method of membrane distillation that holds promise is reverse osmosis. Osmosis is defined as "the spontaneous passage or passive diffusion of water or a solvent through a semi-permeable membrane due to an osmotic pressure" (Wimalawansa, 2013). In the process of reverse osmosis, saline is fed into the system, as shown in Figure 5. This saline then flows through a very fine membrane which only allows pure water molecules to pass through, filtering out the larger salt molecules (Thomson et al., 2001).

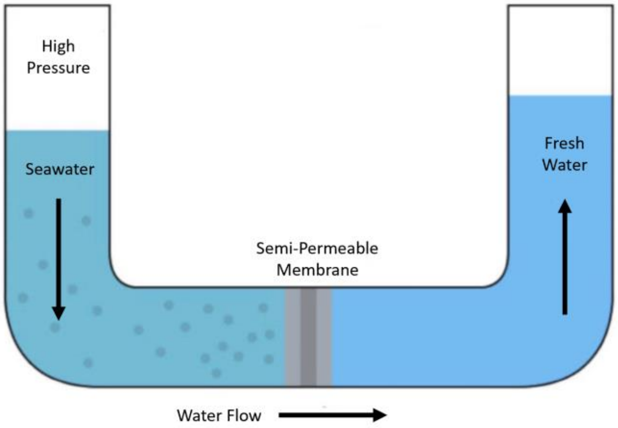

Figure 5 - Diagram of reverse osmosis showing saline flow through a membrane (modified from Thomson et al., 2001)

For the saline to flow, the infeed of seawater must be pressurized (Thomson et al., 2011). When osmosis occurs, the water will flow from the diluted side of the membrane to the concentrated side. To reverse this, saline is pressurized against the membrane, and this causes a reverse in the flow direction of the water. This reversed flow produces fresh water on one side of the membrane and brine on the other. This is the most used and prevalent desalination technology on a world scale (Boden & Subban , 2018). Often reverse osmosis of the saline will be followed by multistage flashing or multi-effects distillation (Alkaisi et al., 2017).

The other membrane desalination process that is commonly used is electrodialysis. In this method, an electric voltage is sent through the saline solution. This results in the positive sodium and negative chloride ions migrating toward the electrodes that have the opposite charge (Petruzzello, 2023). Effectively, this removes the salt from the saline allowing for a freshwater solution to be attained. A diagram of this can be seen in Figure 6. Usually, these systems have hundreds of plastic membranes that selectively allow negative or positive ions through. These membranes alternate, and this creates alternating sections of brine or freshwater (Petruzzello, 2023).

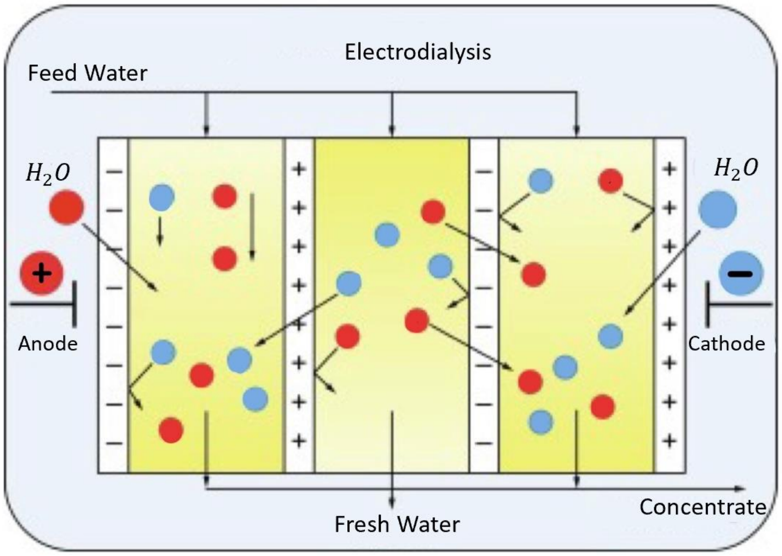

Figure 6 - Schematic of ion exchange occurring within an electrodialysis desalination system (Shatilla, 2020).

The electrodialysis process is a bit more complex to operate than thermal methods, but it does have a lower capital cost. To increase the effectiveness and efficiency of desalination methods and systems, research has been done to attempt to integrate renewable energy into desalination systems (Hamed, 2005). This will be discussed in the following section.

2.2 Incorporation of Renewable Energy into Desalination

Many methods of desalination have the potential to integrate renewable energy. This is of particular interest in scenarios where clean water is in high demand, but access to power sources or fossil fuels is economically inviable. According to a review carried out by researchers at the University of Southern Queensland, on average, producing 1000 cubic meters of fresh water via desalination methods requires roughly 5 tons of crude oil (Alkaisi et al., 2017). If this can be replaced with renewable energies, the emissions produced by the systems will be decreased, and the efficiency and, thus, expenses of the systems could improve (Alkaisi et al., 2017). Current Integration of Renewables

Currently, one of the main renewable energies used in conjunction with desalination systems is solar power. Solar energy can provide both the electricity to operate the desalination system and the heat required for every desalination process (Alkaisi et al., 2017). A method of generating electricity known as solar photovoltaic (PV) takes the suns radiation and converts it into direct current electricity (Bennett, 2011). Commercially this method of generating electricity is packaged with water treatment. One example of this is a system that was developed by Australia Global Trading and CLLEEN Water and Power. This system is a filter-less multistage flash evaporation desalination system, as shown in *Figure 1*, self-powered by solar PV. The energy from solar PV is then stored in batteries and used at night to power the system (Bennett, 2011). This system also happens to be capable of being mobile or stationery. Thus, making it convenient for use in remote locations (Bennett, 2011). Concentrated solar power (CSP) is another method of attaining energy from solar. This method increases solar intensity.

Wind energy is also useful for integration in desalination systems. In coastal areas where the wind is prominent, wind energy can be used to produce electricity. This is then used to power reverse osmosis or electrodialysis desalination since these methods require electricity but not heat (Alkaisi, et al., 2017). Wave or tidal energy is also a suitable method of electricity generation in coastal areas with suitable geography.

Renewable energies can be integrated into both large-scale desalination plants and small-scale desalination systems. Since this thesis aims to look into clean water solutions for disaster relief, small-scale desalination systems integrating renewables will be given more attention. Such systems have the potential to be mobilized in a disaster relief scenario or act as a more temporary solution, unlike a large desalination plant (Leijon & Lindahl, 2021).

2.2.1 Use of Renewable Energy in Small-Scale Systems

Renewable energies have been employed for use in small-scale desalination systems. One main method of small-scale desalination would be the use of a solar still. Solar stills require greater amounts of space the more water one desires to output per day from the still (Godart, 2019). In an article from the Pakistan Institute of Engineering and Applied Sciences, the design and performance of single-basin solar are still discussed. This solar still uses nothing but thermal energy produced by the sun's rays to carry out the evaporation of freshwater from saline (Samee, Mirza, Majeed, & Ahmad, 2007).

In this study, a simple solar still was designed and built; the finished product, while being tested, can be seen in Figure 7. The solar still was then tested and found to have an average output of 1.7 liters/day when left outdoors for eight days. It was concluded that this number could be increased if the efficiency of the solar still was improved by bettering the materials used (Samee, Mirza, Majeed, & Ahmad, 2007). This solar still is an example of how, while it may not be highly efficient, it does provide fresh water without an overly complicated or expensive process.

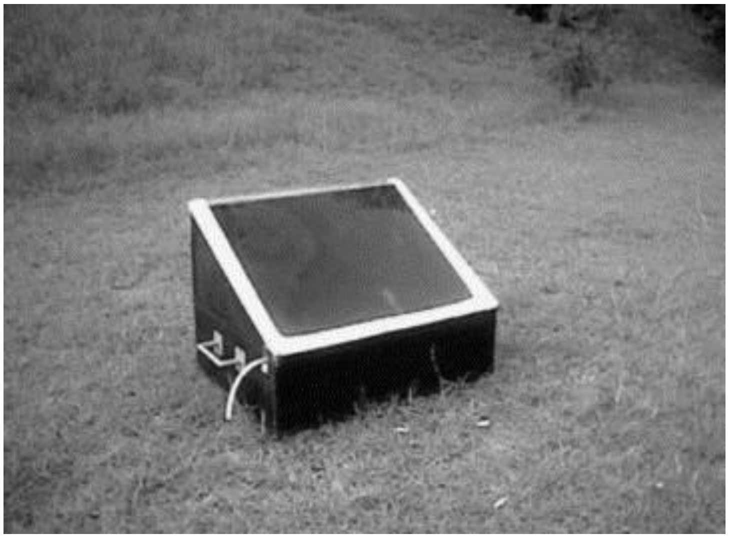

Figure 7 - Solar still being tested outside (Samee, Mirza, Majeed, & Ahmad, 2007)

In a paper written by Peter Godart, a master's student at MIT, it was explained that another solar-still device exists from Aquamate. However, while it is cheap and simplistic, its inefficiency requires that it has a high surface area to produce higher quantities of freshwater. Therefore, it is not as effective when a small-scale system is desired (Godart, 2019).

It should also be noted that there are many combinations of solar energy technology and desalination processes that, if they can be made economically viable, would have applications on a smaller scale. An article published in *Renewable and Sustainable Energy Reviews* explains that solar concentrator collectors are historically used to distill water in compact areas. But with technological developments, evacuated tube collectors and heat pumps have become a financially equivalent replacement for solar concentrator collectors. This replacement gives the potential to use solar energy to desalinate water in a small-scale system (Shatat, Worall, & Riffat, 2013). Within the article, an economic analysis of an evacuated tube solar collector is carried out. It goes on to conclude that the unit, when powered by solar energy systems, is suitable for providing water and electricity to remote areas. The analysis done was for a scenario where the system would be continuously run and act as the source of clean water for a semi-arid climate where water and electricity infrastructure are lacking, but solar energy is abundant (Shatat, Worall, & Riffat, 2013).

Another article written in 2000 by researchers at the Federal University of Paraiba in Brazil presents a strategy to optimize a small-scale desalination system based on solar energy that uses reverse osmosis. While it is acknowledged that this article is fairly dated, the time passed should have allowed for further technological developments and, thus, improvements in the strategies optimized. It was determined by the writers that solar-powered reverse osmosis would be inefficient if power was available from a local grid. But it was also found that using solar power was effective in attaining high-quality freshwater (Laborde, Franca , Neff, & Lima , 2001).

In conclusion, renewable energies can certainly provide the necessary electrical or thermal energy for desalination systems. While it may not be the most efficient possible method, it does accomplish the goal of providing fresh water via a small-scale desalination system.

Chapter 3: Natural Disaster Relief and Desalination Use

3.1 Potential for Desalination

After the occurrence of a marine natural disaster, people affected will often lose access to potable water due to contamination of usual sources by seawater and other pollutants. In addition, affected areas, especially in underdeveloped areas, are difficult to access by usual ground transportation. Therefore, it is difficult and expensive to bring bottled water supplies to those in the area. In addition, natural disasters often knock out electrical grid power and transportation of fossil fuels into the area. Thus, this paper aims to explore the plausibility of having a small-scale desalination system that is self-powered to provide fresh water following natural disasters. It is also important to note that in assessing possible solutions, or a lack thereof, a solution for a constant water supply from desalination is not the goal. The goal is to establish a system or methodology by which desalination could provide temporary relief to an area until the infrastructure can recover from the disaster. Therefore, all of the possible technologies explored may have room for tailoring to short-term use.

Based on research done, the amount of water that desalination systems for natural disaster relief would need to produce would be somewhere between 100 and 1000 liters per day (Godart, 2019). For one solar still mentioned previously that was designed by researchers in Pakistan, that is a far greater volume than the output of 1.7 liters/day that their solar still provided (Mohan, Yadav, Panchal, & Brahmbhatt, 2017). Solar stills, while effective, need a large amount of surface area to produce volumes of up to 100 liters of water per day. Thus, making them unideal when a compact desalination system is desired. However, if an area prone to marine natural disasters had these in place preemptively, it may be beneficial for building up a store of freshwater over a long period of time. Additionally, since solar stills are low maintenance, cheap, and only use rays from the sun, they are a simple way to passively prepare for a marine natural disaster.

A battery-less photovoltaic reverse osmosis system does show promise for fitting the bill. It does not rely on the electrical grid but rather is powered by photovoltaic technology. If built in the way specified by the original designer, the rig is said to be highly efficient and produces $3m^3$ of fresh water per day, which is equivalent to 3000 liters. However, theoretically, this system would require that the area affected by the natural disaster has suitable sun exposure for the photovoltaic solar energy to be attained. If the area were to not have enough sunlight, the efficiency of this system would significantly decrease.

When considering options for providing water after a natural disaster, there is much to consider, as all desalination methods depend on a variety of factors. If solar-powered, sun exposure plays a large role; if membrane methods are used, the salinity and pH of the input seawater will affect the effectiveness of the system. The multifaceted nature of this issue begs the question of whether it is a one size fits all solution. Rather than deeming one method most effective, it may be found that in one coastal region where hurricanes are experienced, a solar still is a better approach, while in another area of the world, a reverse osmosis system is better.

3.2 Integration of Desalination into Preparation for Natural Disasters

In implementing the use of desalination systems in natural disaster relief, extensive planning would have to be done to establish a course of action. After the development of an effective self-powered, small-scale desalination system, there would be much to be discussed.

Firstly, would this system be brought in in high quantities after a marine natural disaster by a nonprofit organization, a government, or another company entirely? Would these systems even be shipped in, or would they be purchased ahead of time by areas prone to marine natural disasters as a step towards preparedness? Just as the decision on which desalination system would be best suited to provide freshwater has many approaches, so does the path of implementing such technology in natural disaster response.

Chapter 4: Conclusions and Future Work

4.1 Conclusions

Based on the exploration, it is concluded that various technologies, specifically reverse osmosis and solar stills, show potential for providing clean water in the wake of a marine natural disaster. That being said, it is also noted that for any of these technologies to be implemented, further research is necessary. Not only to determine what energy source should be used in combination with a desalination system but also to determine how exactly the system would be used in disaster relief. While desalination is not a perfect solution, its potential to combat the water crisis and provide those in need with access to clean water is undeniable. Piquing the interest of others within the fields of engineering and science in desalination potential for use in humanitarian work and disaster relief is paramount to the continued research of this topic. Desalination, on a small scale, when able to be self-powered by renewable energies, holds the key to helping those in need across the globe.

4.2 Future Work

There is still much research and work to be done in desalination. In particular, more research would have to be conducted to determine its effectiveness in marine disaster relief. Currently, a gap exists in the research and experimentation with small-scale desalination systems. There are studies on the efficiency and financial benefits of desalination over long periods of time on larger scales. However, little to no research has been done on the short-term use of small-scale desalination. In the case of natural disaster relief, long-term efficiency and economic feasibility is not the driving component of choosing how to supply freshwater best. Disaster relief focuses on meeting the immediate needs of those impacted. Therefore, future work should focus on how effective small-scale desalination systems that integrate renewable energies can provide immediate relief.

Further, more focus could be placed on the development of membrane technologies. The more efficient membrane technologies are, the more effective reverse osmosis will be in providing freshwater. Looking at the future, there is hope that desalination will develop into a trusted means of providing clean water post marine natural disasters. If today's technology can give humanity a chance to experience life in space, surely it can provide a way to give those across the globe access to clean water.

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