Transforming New Orleans: Innovative Water Desalination and Fertilizer Production for a Sustainable Future

Balancing Sustainability and Equity in Desalination: A Sociotechnical Analysis for New Orleans, Louisiana

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

In recent years, there has become an imminent threat of saltwater intrusion into the New Orleans, Louisiana, area's freshwater supply. This threat is due to changes in the flow and composition of the Mississippi River. According to SPHTM Communications (2023), a lack of rainfall in the Midwest has resulted in lower river flow in the Mississippi, allowing denser saltwater from the Gulf of Mexico to move upstream, contaminating the freshwater supply. The current New Orleans water system does not filtrate salt. This new increase of saltwater entering their water system could lead to the corrosion of pipes, leaching heavy metals from the pipes into drinking water. Along with this issue, agricultural concerns also exist. Large acreage farmlands irrigated by the lower Mississippi River have already begun facing hardships due to its low levels and increased salinity. These issues will both be addressed in the technical design project. In later sections, more detail will be presented in the design of a water desalination and fertilizer production plant using water from the Gulf of Mexico.

Desalination involves the removal of salt and impurities from seawater to make it suitable for drinking and irrigation. There are many environmental impacts that coincide with this type of process. The desalination process typically relies on technologies like reverse osmosis or distillation, which can be very energy-intensive processes. Due to the significant amounts of energy required to run a plant like this, energy used to power the plant is typically derived from non-renewable sources like fossil fuels. The high energy consumption contributes to greenhouse gas emissions and air pollution, which can harm both local and global environments. Along with high energy consumption, running this process also has an impact on marine ecosystems. Intake and discharge of seawater during the desalination process can harm ecosystems by entrapping or releasing marine life, disrupting local aquatic habitats, and affecting water temperature and salinity in the vicinity of the plant (EPA, 2016). Improper disposal of brine byproduct, concentrated salty solution, can also harm local aquatic ecosystems.

Desalination does not only have environmental implications, but also equity and social impacts. When implementing desalination as a solution, ensuring equitable access and addressing potential social disparities is crucial. It's essential to ensure that the clean drinking water produced by the desalination plant is affordable and accessible to all residents of New Orleans, regardless of their socio-economic status. Equity concerns may arise if the cost of desalinated water is prohibitive for some segments of the population. The location of where the plant is also plays an important role. The location of desalination plants can have a significant impact on nearby communities. These communities may experience environmental disruption, such as increased noise, altered coastal landscapes, or air pollution from energy generation. Ensuring that the concerns of these communities are addressed and that they benefit from the project is a sociotechnical challenge.

The two topics discussed in this introduction, saltwater intrusion into the New Orleans freshwater supply and the proposal for a desalination and fertilizer production plant, are linked by the overarching issue of water resource management in the face of changing environmental conditions. Saltwater intrusion poses a significant threat to the freshwater supply of New Orleans. This environmental challenge directly impacts the city's residents and infrastructure, as it jeopardizes the quality of their drinking water and the integrity of their water distribution systems. The proposed desalination and fertilizer production plant represents a technological solution to address the issue of freshwater contamination. Desalination is a promising approach to secure a freshwater source in regions facing saltwater intrusion. By utilizing seawater from the

Gulf, the proposed plant aims to ensure a reliable source of freshwater for New Orleans, reducing the dependence on the increasingly vulnerable Mississippi River.

These two topics are interconnected through the concept of sustainable water resource management. The threat of saltwater intrusion warrants innovative solutions like desalination to ensure a continued supply of clean water for New Orleans residents. However, desalination comes with its own set of environmental and social challenges, which need to be carefully addressed in the design and implementation of such a system. This sets the stage for a comprehensive examination of these intertwined challenges and the proposed engineering solutions.

Technical Aspects of Desalination and Fertilizer Production

According to the World Health Organization (WHO), “ [approximately] 2.2 billion people around the world do not have safely managed drinking water services, 4.2 billion people do not have safely managed sanitation services, and 3 billion lack basic handwashing facilities” (World Health Organization, 2019). However, implementation of desalination plants could be a step towards a solution. Today’s desalination technology is controversial due to its impending environmental hazards and costly overhead. In general, the quantity of drinking water that these plants produce is almost equivalent to the waste they create. This waste is generally produced in the form of concentrated brine as a byproduct of reverse osmosis (RO). Conventional methods have typically pumped this brine waste back into the ocean, however this method not only disturbs marine life but also exacerbates climate change by significantly increasing the salinity of the water. Our motivation for this project includes the following: preventing further salination of the Mississippi River; providing a clean water source to residents of New Orleans, LA; and utilizing excess brine waste as a renewable resource. Overall, by the end of this project our desalination plant will be able to produce sufficient drinking water to the population of New Orleans while also utilizing excess brine waste as a raw material for fertilizer and road salt.

Technical Problem

This project consists of treating seawater from the Gulf of Mexico to create drinking water and agricultural fertilizer for the city of New Orleans. To start, the salty seawater will go through a pretreatment process. During this phase the water will undergo coagulation, pH adjustments, filtrations, and disinfection as shown in Figure 1. Filtration using granular media and low-pressure membrane filtration have been selected as the desired filtration methods due to their regular and supported use (Prihasto, 2009). Following the pretreatment stage, the newly treated seawater will undergo reverse osmosis (RO) to remove the salt and other contaminants from the seawater. RO will result in two outlets: brine solution and fresh water, each to be used for a different purpose.

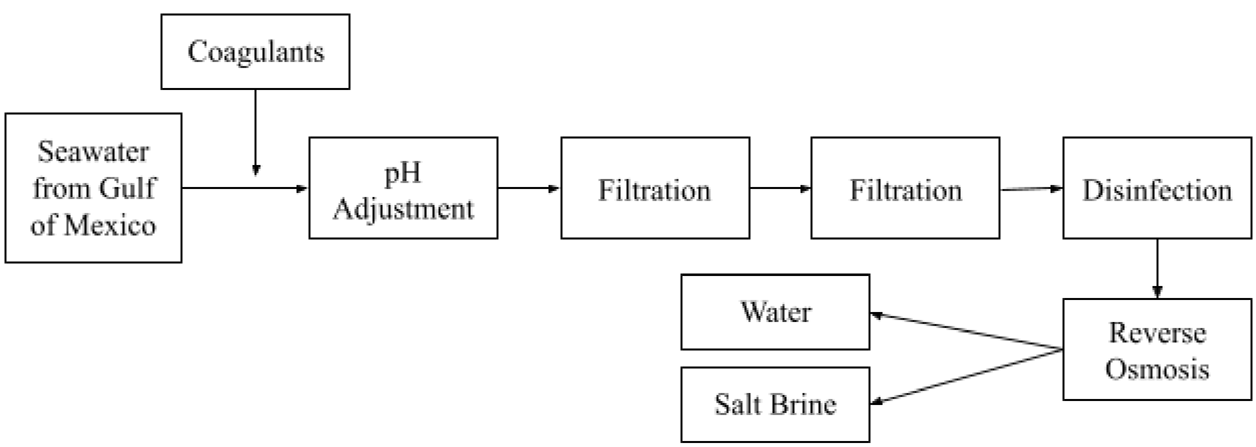

Figure 1. Pretreatment Process for the Seawater to Going Through RO

The salt brine solution will undergo various filtration processes in addition to being mixed with phosphoric acid and ammonia to create both salt that can be used on the roads to melt ice and fertilizer that can be used in agriculture in New Orleans. This process was inspired by the work of William B. Hughes. He proposed a process that consisted of taking oil field waste brine, adding both phosphoric acid and ammonia, and then drying out the filtered brine to form an end result of ammonium phosphate precipitate fertilizer and salt (Hughes, 1984). We will be using a similar approach but instead of using oil field salt brine, we will be using the salt brine from our reverse osmosis process. This process is laid out in more detail in Figure 2. The difference between our process and Hughes's proposed idea is that we will be using RO to separate the salt from the resulting brine water post-phosphoric acid and ammonia addition. Additionally, we will be using different methods of mixer that will hopefully conserve energy in the process.

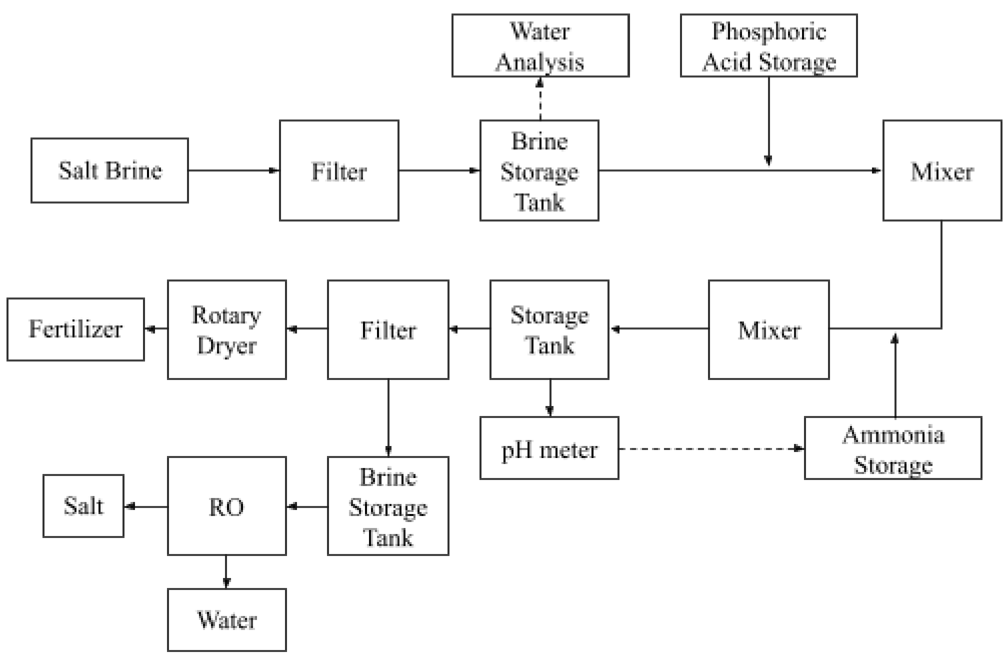

Figure 2. Salt Brine to Fertilizer Process

Furthermore, post treatment will be required for water exiting RO to maintain potable water standards. Post treatment consists of recarbonation, chlorination, and pH adjustments.

After post treatment, fluoride and lime will also be added to the water to improve quality of taste as per the “2022 Annual Water Quality Report” put out by Sewerage & Water Board of New Orleans (Reports, 2022). The proposed idea for the post treatment process can be found below in Figure 3.

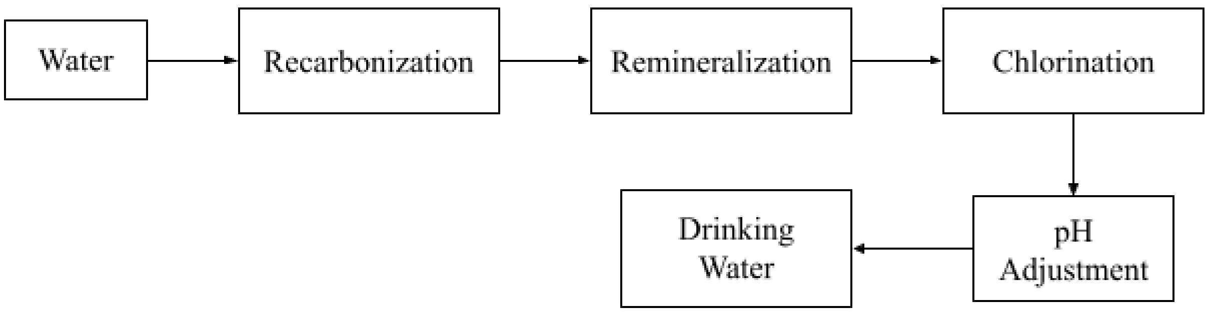

Figure 3. Post Treatment Process Forming Drinking Water

Environmental Sustainability and Equity in Saltwater Intrusion Mitigation

As stated before, desalination is a great approach for making clean drinking water from seawater, but it comes with its own set of obstacles including the environmental and equity impacts. The goal of more socio-technical research is to be able to answer the following question: How can the implementation of desalination technology for clean drinking water in regions facing saltwater intrusion be approached in a way that addresses both environmental sustainability and equity concerns?

This research question is important due to the growing global challenges related to freshwater scarcity and the increasing impact of climate change on coastal communities. Saltwater intrusion threatens the availability of freshwater resources in many regions, making the adoption of desalination technology an urgent necessity. However, the potential environmental and equity issues associated with desalination must be thoroughly examined to ensure that this technology is not only effective but also socially and environmentally responsible.

Saltwater intrusion occurs when saline water from sources like the ocean, or in this case the Gulf of Mexico, infiltrates freshwater bodies, contaminating the freshwater supply. This phenomenon is worsened by factors such as reduced river flow, sea-level rise, and increasing demand for freshwater. On top of these issues, land in coastal Louisiana has been sinking at a rate of about one inch every three years (EPA, 2016). This subsidence, combined with rising sea levels, is contributing to land loss. The EPA (2016) writes about the potential effects on water quality due to increasing acidity and warmer surface temperatures in the ocean. Because of this, New Orleans, Louisiana, serves as a pertinent case study, where changing conditions in the Mississippi River have led to heightened saltwater intrusion, affecting both the city's freshwater supply and agricultural practices.

Desalination offers a solution to this problem by transforming seawater into clean drinking water. However, the sociotechnical challenges related to desalination are multifaceted. The high energy consumption in desalination is typically met by the burning of fossil fuels, such as natural gas or coal. This reliance on non-renewable energy sources leads to the release of greenhouse gasses into the atmosphere, contributing to climate change and global warming, which have far-reaching environmental consequences. Along with the high energy consumption, there are detrimental impacts on marine ecosystems. The intake of seawater during the desalination process can unintentionally trap marine organisms present in the water. This includes fish larvae, plankton, and other microorganisms, causing these organisms to be harmed or killed. The discharge of brine back into the ocean can also impact marine life, as the higher salinity water can negatively affect the local ecosystem.

On top of environmental impacts, there are equity and social impacts to implementing a desalination process. Ensuring equitable access to clean water is essential. This means that the cost of desalinated water should not be prohibitively high for any segment of the population. This is extremely important given that New Orleans has the highest official poverty rate among the 50 largest metro areas in the United States (Total Community Action Inc, 2018). The location of the desalination plant will have various impacts on these impoverished communities such as increased noise, changes in coastal landscapes, or air pollution. It is critical to engage with these communities, address their concerns, and involve them in the decision-making process to ensure they benefit from the project and are not disproportionately burdened by its presence.

The research will involve a multidisciplinary approach, drawing from environmental science, engineering, social science, and policy analysis. A comprehensive analysis will include environmental impact and equity assessment. Data on energy consumption, greenhouse gas emissions, and air quality will be collected and analyzed to see the effects. The collected evidence will be interpreted through the lens of environmental impact assessments and social equity frameworks. Comparisons and evaluations will be made to determine the overall impact of desalination on both the environment and the community. The research will provide valuable insights into how desalination can be implemented as a sustainable and equitable solution to saltwater intrusion.

Conclusion

In conclusion, the imminent threat of saltwater intrusion into the freshwater supply of New Orleans, Louisiana, requires a current need for innovative solutions. Desalination technology offers a promising remedy, but it brings forth significant environmental and equity challenges. To address these complex issues, the technical design project outlines a comprehensive approach to transforming Gulf of Mexico seawater into clean drinking water while utilizing excess brine waste for fertilizer and road salt production. This research seeks to mitigate the environmental implications of desalination and promote equitable access to clean water. By addressing both environmental sustainability and social equity, the aim is to provide a plan to ensure a more secure future for the residents of New Orleans.

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