

Water, Waste, and Society: STS Analysis of Desalination and Brine Repurposing

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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

Water scarcity proves to be an issue all over the world. To combat this problem, the implementation of desalination plants prove to be a promising solution to provide freshwater. Due to saltwater intrusion up the Mississippi River, Louisiana, specifically New Orleans's freshwater source is being threatened. The Gulf Coast region struggles, needing an innovative solution to ensure sustainable water resources. In this landscape, desalination emerges as a potential technology to address water shortages. However, the implementation of desalination plants comes with environmental and social considerations, especially in a region known for its ecological sensitivity and cultural diversity.

The central research question steering this analysis is as follows: What are the environmental and human effects of implementing a desalination plant in New Orleans, Louisiana, with a specific emphasis on the reclamation of brine waste for fertilizer production? This question explores the entanglement of technological innovation and the consequences of its implementation on both the local ecosystem and local community. Typical disposable methods of brine, including dumping waste directly back into the ocean, are harmful to the environment. Along with that, the environmental changes resulting from desalination can have indirect effects on community health and livelihoods. For example, alterations in water quality may impact fisheries and other industries reliant on the local ecosystem, affecting the economic well-being of the community. In reclaiming the brine for fertilizer and rock salt production, there are hopes that conventional harms can be avoided. The proposed solution however, has its own set of harms that need to be further explored.

There are some important groups of people that play a huge role in influencing, shaping, and responding to the execution of this process. The key actors in this research are the local

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communities in New Orleans directly affected by water scarcity, policymakers involved in water resource management, environmental agencies overseeing the Gulf Coast's fragile ecosystem, and the scientific community engaged in developing and implementing desalination technologies. The local communities' experiences and concerns are critical lenses to look through when measuring the success or challenges of the proposed plant. The policymakers hold great authority in shaping the legal landscape within which the desalination plant operates. The expertise of the environmental agencies will ensure that the project aligns with conservation goals and avoids unintended consequences on the Gulf Coast's diverse ecosystems. Lastly the scientific community forms the basis of technical knowledge that will be needed to confirm that the project integrates the latest sustainable practices, minimizing environmental impacts while maximizing the benefits to the local communities.

Through an in-depth examination of the implementation of desalination technology in New Orleans, this research aims to shed light on the complicated relationship between environmental sustainability and human well-being. By focusing on the reclamation of brine waste for fertilizer production, the study seeks to evaluate the broader implications on local ecosystems, water quality, and the community. The findings are anticipated to provide valuable insights for policymakers, community stakeholders, and scientists, contributing to a more comprehensive understanding of the potential benefits and challenges associated with desalination in the unique context of New Orleans.

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Background

In a world struggling with the prevalent challenge of millions lacking access to safe drinking water and basic sanitation services, the global water crisis remains a pressing concern. While this issue is often associated with developing nations, the United States, despite its developed status, faces a unique water crisis that jeopardizes the well-being of its communities. From aging water infrastructure to contamination concerns in both urban and rural areas, the crisis manifests in various forms. Recent data from Time Magazine reveals a stark reality – nearly half a million U.S. households lack complete plumbing, while many more reside in communities that deal with unclean water (Time, 2023). This highlights the urgency of addressing water-related issues even within affluent nations. It is becoming imperative to address this issue for safeguarding public health, environmental sustainability, and ensuring access to clean and safe drinking water for all citizens.

A place many people would never consider to have a drinking water crisis is in “The Crescent City”. New Orleans, Louisiana, is a city that is intrinsically linked to the Mississippi river. While the city is famed for its vibrant culture and iconic celebrations, it faces a severe water challenge. The river, a lifeline for New Orleans and the surrounding region, is threatened by saltwater intrusion from the Gulf of Mexico.

Saltwater intrusion is a pressing concern in coastal regions. It becomes particularly prominent when factors such as a lack of rainfall come into play. In the context of the Mississippi River, reduced rainfall worsens the intrusion of saltwater from the Gulf of Mexico into the freshwater reaches of the river. Too little precipitation diminishes the river's freshwater flow, allowing saline water to advance inland. This phenomenon is a result of an imbalance between the river's outflow and the seawater's intrusion. The consequences are varied, affecting both

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ecosystems and human communities dependent on the river for freshwater. Coastal aquifers and surface water sources, crucial for agriculture and municipal water supplies, face increased salinity, threatening the quality of water accessible to the city.

The aim of the technical capstone project is to tackle this water scarcity crisis. As the area deals with the growing demand for freshwater, desalination has emerged as a critical solution. This technical project explores the design of a desalination plant in New Orleans, which would use advanced processes, including reverse osmosis, to turn saltwater from the Gulf of Mexico into clean, drinkable water. While desalination technology offers a promising solution, it comes with its own set of challenges, particularly the production of concentrated brine waste. The brine waste, when not managed properly, can exacerbate environmental issues.

Brine waste presents a significant environmental challenge due to its high salinity and chemical residuals (Panagopoulos, 2020). Conventionally, this waste is discarded into the ocean, disrupting marine ecosystems and contributing to environmental degradation. However, the technical project introduces a transformative approach by utilizing brine waste to produce valuable resources, particularly agricultural fertilizer. This innovative approach was inspired by a patent written by William B. Hughes (Hughes, 1984). Repurposing brine waste into fertilizer represents a revolutionary and sustainable solution that not only mitigates the negative environmental impact of traditional disposal but also contributes to enhanced resource efficiency. The utilization of brine waste in fertilizer production not only minimizes its detrimental effects on marine environments but also turns it into a valuable asset for agricultural practices.

Along with environmental challenges and effects, implementing a desalination plant can have effects on a community, both positive and potentially challenging. On the positive side, the introduction of a desalination plant addresses critical water scarcity issues, providing a reliable

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source of clean and potable water. This directly enhances the quality of life for community members, ensuring access to a consistent and secure water supply. Moreover, the economic landscape may see positive shifts as the desalination plant creates job opportunities and stimulates local industries, particularly in the water and technology sectors. However, challenges may arise as well. The environmental impact of desalination, particularly the disposal of brine waste, requires careful management to prevent harm to marine ecosystems. Additionally, there might be concerns about the energy consumption of desalination processes and potential disruptions to local ecosystems during plant construction. Effective community engagement and transparent communication throughout the implementation process are crucial to addressing concerns and ensuring that the benefits of a desalination plant are maximized while minimizing potential drawbacks.

The interplay between the technical and sociotechnical problems is evident – while the technical project aims to provide clean drinking water, safeguarding against the threats of saltwater intrusion, the Science, Technology, and Society (STS) research element turns an environmental challenge into an opportunity. This research analysis reframes the narrative and views the environmental challenge of brine waste not merely as a problem but as an opportunity for sustainable resource management. This holistic approach not only mitigates the harmful impact of brine waste but also establishes a model for sustainable practices, embodying the project's commitment to environmental responsibility and the maximization of resources for the benefit of society. The teamwork between technical and sociotechnical components illustrates the project's work in navigating complex environmental challenges and highlights the significance of interdisciplinary solutions in fostering a more sustainable and resilient future.

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Methodology

In tackling my research question, "What are the environmental and human effects of implementing a desalination plant, particularly concerning the reclamation of brine waste for fertilizer production in New Orleans, Louisiana?" I adopted a comprehensive and systematic approach that incorporates both a utilitarian framework and a combination of literature review and surveys to gather information.

The utilitarian view, as the analytical framework guiding my research, positions the assessment of environmental and human effects within the broader context of maximizing overall well-being. This ethical perspective prioritizes the greatest good for the greatest number, emphasizing the consequences and benefits that arise from the implementation of a desalination plant. By adopting a utilitarian lens, I aim to evaluate the net positive or negative impacts on the community and the environment, considering both short-term and long-term consequences.

The literature review served as a foundational pillar of my research approach, allowing me to explore existing research studies and expert opinions related to desalination plants, environmental impacts, and human well-being. This extensive study of literature helped me establish a solid theoretical foundation, understand existing methodologies, and identify gaps in the current knowledge. Utilizing insights from established literature enabled me to refine my research questions, frame hypotheses, and draw comparisons with similar projects globally. Comprehensive literature review was helpful in informing the contextual nuances of desalination projects and their potential effects on both the environment and the community.

Supplementing the literature review, surveys emerged as a vital methodological tool to gather empirical data and insights on how people view desalination. Recognizing the importance of incorporating real perspectives and experiences, surveys allowed me to engage with people

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and get their opinions on the implementation of a desalination plant. By employing surveys, I could collect quantitative and qualitative data on public perceptions, concerns, and expectations regarding the environmental and human effects of such a project. This approach ensures that the research findings are not solely grounded in theoretical frameworks but also incorporate the lived experiences and viewpoints.

The choice of surveys aligns with the utilitarian view, as it facilitates the understanding of the overall utility or well-being generated by the proposed desalination plant within the community. The responses gathered through surveys contribute valuable insights into the potential social, economic, and environmental consequences, helping to balance the utilitarian calculus and identify potential trade-offs or conflicts in maximizing overall welfare.

In short, my approach to the research question combines a utilitarian view with a dual methodology of literature review and surveys. This strategy aims to provide an all-inclusive understanding of the environmental and human effects of implementing a desalination plant in New Orleans. The utilitarian framework ensures a balanced evaluation of consequences and benefits, while the literature review and surveys collectively contribute theoretical foundations and empirical data, enriching the depth and breadth of the research. This approach integrates ethical considerations, theoretical insights, and community perspectives, offering a comprehensive analysis of the complex relationship between technology, society, and the environment.

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Discussion/Results

The literature review combined with surveys revealed various environmental and human effects associated with the implementation of desalination plants, especially concerning brine waste management and reclamation for fertilizer production. Environmental impacts include increased salinity levels in water bodies, disruption of marine ecosystems, and greenhouse gas emissions. However, the reclamation of brine waste for fertilizer production presents an opportunity to mitigate environmental harm and promote sustainable agricultural practices. Human health concerns arise from elevated sodium levels and the presence of disinfection byproducts in desalinated water, necessitating careful monitoring and regulation. Community engagement considerations are crucial for addressing environmental justice concerns and ensuring equitable access to water resources. Effective policy and regulatory frameworks are essential for governing desalination activities and safeguarding environmental and human well-being.

Environmental Effects

The implementation of a desalination plant in New Orleans, Louisiana, carries significant implications for the environment. Desalination offers a promising solution to address water scarcity issues in regions vulnerable to drought or in water stress, such as New Orleans. However, the process of desalination uses large amounts of electricity and generates brine waste, which poses environmental challenges if not managed properly.

Desalination processes produce concentrated brine as a byproduct through the use of reverse osmosis to remove salt from seawater. This brine is commonly disposed of into surrounding oceans and seas, as most desalination plants are located on the body of water from which they are getting salt water (Omerspahic, 2022). This method of brine disposal into natural

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bodies of water can have adverse environmental consequences (Omerspahic, 2022). The negative effects that can result are increased salinity levels, increased water temperatures, disruption of marine ecosystems, and harm to aquatic organisms (Omerspahic, 2022). Despite the harsh effects on the environment, it is important to note that the production of brine as a by-product of seawater desalination is almost entirely unavoidable.

One of the most immediate and pronounced impacts of brine discharge is the increase in salinity levels in receiving waters. Elevated salinity can disrupt the delicate balance of aquatic ecosystems, affecting both marine flora and fauna. While some species may thrive in higher salinity waters, many will struggle and die off. High salinity levels can inhibit the growth of sensitive aquatic plants and algae, disrupt the reproductive cycles of marine organisms, and alter species composition (Omerspahic, 2022). Large alters to salinity can result in species adapted to lower salt levels to migrate away to areas with more suitable conditions. Increased salinity may affect sediment transport, leading to changes in coastal morphology and sedimentation patterns (Omerspahic, 2022). The implementation of a plant near New Orleans has the possibility of worsening the issue that is causing a need for the desalination plant in the first place. Along with that, salinity variations in the Gulf of Mexico can interact with larger climate patterns, such as ocean circulation and atmospheric processes (Olson, 2022). Changes in salinity may contribute to regional climate variability and influence weather patterns in surrounding areas.

While desalination has many negative impacts, the environmental cost can be minimized through sustainable practices and technological innovations. Research by Ogunbiyi and others highlights the importance of developing sustainable brine management strategies (Ogunbiyi, 2021). Various methods of disposal of brines have been explored including solar evaporation, distillation, controlled release of brines into surface waters, and injection of brines into surface

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waters (Hughes 1984). Many of these approaches become difficult in areas with high rainfall and increasing regulatory pressures coming from the state and federal levels (Hughes, 1984).

Reclamation of brine waste for beneficial reuse, such as fertilizer production, presents a promising approach to minimize environmental harm. There are many valuable minerals that exist within the brine, and recovery of these minerals has not yet been fully harnessed or explored (Ogunbiyi, 2021). The retrieval of these minerals can limit the amount of brine waste, helping the marine environment while also presenting an economic benefit of a sellable side product.

Brine contains valuable nutrients, including potassium, magnesium, and calcium, which can be utilized in fertilizer formulations (Elimelech & Phillip, 2011). Along with that, the brine contains many divalent metal ions (Hughes, 1984). These essential nutrients are vital for plant growth and development. Several studies have investigated the feasibility and effectiveness of extracting these nutrients from brine waste and incorporating them into fertilizers (Irwin, 2020). By transforming waste into a valuable resource, brine reclamation for fertilizer production not only reduces environmental pollution but also contributes to sustainable agriculture practices.

It is also important to note that the generation of fertilizer also has adverse effects on the environment. One significant concern is nutrient runoff, where excess fertilizers applied to fields can be washed away by rainfall or irrigation water, eventually finding their way into rivers, lakes, and oceans. This runoff carries high concentrations of nitrogen and phosphorus, which can lead to eutrophication—the excessive growth of algae and aquatic plants. As these algae and plants die and decompose, they consume oxygen, creating "dead zones" where aquatic life struggles to survive. According to the Environmental Protection Agency (EPA), nutrient pollution from fertilizers is one of the leading causes of water quality degradation in the United

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States, affecting thousands of miles of rivers and streams and millions of acres of lakes, reservoirs, and estuaries (US EPA, 2018).

Furthermore, the use of fertilizers can contribute to soil degradation and loss of biodiversity. Continuous application of fertilizers without proper soil management practices can lead to soil acidification, nutrient imbalances, and decreased soil fertility over time. This can impair soil structure and microbial activity, reducing its ability to support healthy plant growth and ecosystem functions. Additionally, the runoff of fertilizers can disrupt soil and water ecosystems, leading to shifts in species composition and loss of biodiversity (US EPA, 2018). A study published in a special issue of *Sustainable Soil Health Management* highlighted the negative impact of synthetic fertilizers on soil biodiversity, emphasizing the importance of adopting sustainable agricultural practices to mitigate these effects and preserve ecosystem health (M. Tahat, 2020).

In conclusion typical brine disposal methods are extremely harmful to the environment so it is imperative to find a more sustainable approach. Utilizing the brine to make fertilizer is that, but also has its own negative effects on the environment. When looking at the situation through a utilitarian lens, it is important to decide which is the lesser of two evils. Despite fertilizer also being harmful to the environment, using brine to make it is arguably less harmful than conventional brine disposal methods.

Human Effects

In addition to environmental considerations, the implementation of a desalination plant in New Orleans raises concerns about potential human health impacts. While desalinated water offers a reliable source of freshwater, certain aspects of the desalination process and its byproducts can impact human health and safety.

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The human consumption of desalinated water has been subject to scrutiny. Desalination processes, particularly reverse osmosis, are effective at removing contaminants from seawater, providing clean drinking water. However, the process can also lead to elevated sodium levels in the final product (Postel, 2012). This may be of concern for individuals on sodium-restricted diets or those with hypertension. Excessive sodium intake has been linked to various health issues, including high blood pressure and cardiovascular disease (CDC, 2023). Furthermore, the treatment of seawater during the desalination process can result in the formation of disinfection byproducts (DBPs). These byproducts can pose real health risks to consumers. DBPs are compounds that form when disinfectants, such as chlorine, react with organic matter present in seawater (Eslamian, 2014). Some DBPs, such as trihalomethanes and haloacetic acids, are known carcinogens and can also cause reproductive and developmental effects (Eslamian, 2014). Therefore, it is crucial to employ effective water treatment methods and monitoring protocols to minimize DBP formation and sodium levels to ensure the safety of desalinated water for human consumption.

Along with considering the health hazards that are associated with desalination, it is important to consider the community engagement of those affected by the construction of such a plant. The successful implementation of a desalination plant in New Orleans requires active community engagement. In a survey that was conducted by the Institute of Marine Sciences at the University of California Santa Cruz, it was found that 71.9% of residents reported support for the newly constructed desalination plant in Carlsbad, California (Heck, 2016). Having community support like the Carlsbad desalination plant is crucial because it ensures that local residents are actively engaged in the decision-making process, fostering transparency and accountability in the project's implementation, and helps to address concerns and mitigate

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potential conflicts regarding environmental impacts, water quality, and socioeconomic factors associated with the desalination plant's operation. Environmental justice concerns may arise regarding the siting of the plant and its potential impacts on marginalized communities (Pellow & Brulle, 2005). Having community support will help in addressing these concerns. Meaningful stakeholder participation and transparent communication can empower communities to voice their concerns and influence project outcomes.

Another human effect is the policy and regulatory frameworks that get put in place for desalination plants. Utilitarianism provides a basis for evaluating these frameworks that govern desalination activities. Effective governance mechanisms aim to maximize societal welfare by balancing environmental and social considerations. Policymakers must develop comprehensive regulations addressing brine disposal, water quality standards, and environmental monitoring protocols. Regulations should specify permissible discharge locations, volume limits, and concentration thresholds to prevent adverse effects on aquatic ecosystems (Rahm, 2014). Regulatory agencies should also establish maximum contaminant levels for various constituents, including salts, metals, disinfection byproducts, and emerging contaminants. Continuous monitoring and testing of desalinated water are necessary to verify compliance with established standards and identify potential health risks (Eslamian, 2014). By establishing clear guidelines and enforcement mechanisms, policymakers can mitigate environmental harm and hold desalination operators accountable for compliance.

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Conclusion

In examining the environmental and human effects of implementing a desalination plant in New Orleans, Louisiana, with a specific emphasis on the reclamation of brine waste for fertilizer production, several key insights emerge. Firstly, the environmental consequences of traditional brine disposal methods, such as direct discharge into natural water bodies, can be significant, leading to increased salinity levels, disruption of marine ecosystems, and harm to aquatic organisms. However, the reclamation of brine waste for fertilizer production presents a promising opportunity to mitigate these impacts and promote sustainable agricultural practices. While this approach offers potential benefits, it is essential to acknowledge the environmental challenges associated with fertilizer production and nutrient runoff, which can contribute to water pollution and soil degradation.

Additionally, the implementation of a desalination plant in New Orleans raises concerns about potential human health impacts, particularly regarding sodium levels and disinfection byproducts in desalinated water. Effective water treatment methods and monitoring protocols are crucial for ensuring the safety of desalinated water for human consumption. Also, community engagement is essential for addressing environmental justice concerns and fostering transparent communication and accountability in the project's implementation.

From a utilitarian perspective, evaluating policy and regulatory frameworks governing desalination activities is essential for maximizing societal welfare. Effective governance mechanisms should aim to balance environmental protection with social considerations, ensuring that regulations address brine disposal, water quality standards, and environmental monitoring protocols comprehensively. By establishing clear guidelines and enforcement mechanisms,

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policymakers can mitigate environmental harm and safeguard human health while promoting the sustainable use of water resources.

In conclusion, the implementation of a desalination plant in New Orleans, Louisiana, presents both opportunities and challenges for addressing water scarcity and ensuring environmental sustainability. By reclaiming brine waste for fertilizer production and adopting comprehensive policy and regulatory frameworks, stakeholders can minimize adverse environmental and human impacts while maximizing the benefits of desalination for the local community. Moving forward, it would be beneficial to explore the demographics that will be most harmed through the implementation of desalination. That is an angle that was not looked at in this paper, but is an interesting approach when considering utilitarianism.

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