Prospectus

Reverse Osmosis Membrane Utilized in Janicki Omni Processor Wastewater Treatment Process

(Technical Topic)

West Point Wastewater Treatment Plant Failure in Seattle, WA

(STS Topic)

By

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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

The water treatment process is an essential part of how humans are able to obtain clean drinking water. Around 783 million people are living without clean water and almost 2.5 billion people around the planet do not have access to a water sanitation system (Poon, 2015). According to the World Health Organization, the improper treatment and disposal of human waste from 4.5 billion people worldwide has led to the recent rise of polio, cholera, and numerous other diarrheal diseases (Burga, n.d.). Many of these diseases are most widespread in countries where toilets are emptied into local rivers without any clear system for managing the waste.

The Janicki Omni Processor (JOP), developed by Sedron Technologies and funded by the Bill and Melinda Gates Foundation, solves the problem of sustainable water sanitation and treatment all-in-one (Cashman, 2020). It takes an undesirable feed, human waste, and turns it into drinking water, a human necessity. Engineers have been dealing with simple wastewater management for years. But, no one has successfully tackled a self-sustainable system at this caliber. Wastewater treatment plants use an excessive amount of energy leading to high operating costs. To combat this, the JOP generates its own power that goes back into powering the system itself.

However, in order for a wastewater treatment system to remain sustainable in the long run, there are several actors that must be understood. For a wastewater system, equipment failure could cause the demise of the system. Yet, handling and managing the failure is the key to eradicating risks. Some social factors include poor plant safety culture and a lack of employee training that can ultimately lead to plant failure. Such was the case in the failure of the West Point wastewater treatment plant in Seattle, Washington. If a wastewater system cannot remain sustainable, the people relying on this facility will not have clean water. They also will not have access to reliable sanitation which could lead to more diseases, and thus disproportionately affecting poorer communities.

As a result of my analysis, I will be able to delve into a sustainable wastewater system with the JOP which utilizes reverse osmosis (RO) water filtration to ensure clean drinking water as a product. I argue that creating a sustainable wastewater treatment plant is socio-technical in nature and requires a solution that addresses both its technical and social aspects. More specifically, the JOP converts human waste into drinking water and will be able to create its own power to stay running. For the social solution, a better workplace with importance on safety culture and employee training is the root of a long-term system that ultimately will reduce risks and potential for failure; paying attention to this would have saved the West Point wastewater plant.

Below, I outline a technical process for the JOP process that utilizes an RO filtration system which will then be scaled up to accommodate for a city of approximately 1,000,000 people. I also use actor-network theory to analyze the aspects of an unstable wastewater plant which leads to a potential failure. I will explore the human and non-human actors that play a role in ensuring a stable network to protect the machine, employees, and surrounding communities as well.

Technical Problem [1]

Access to clean drinking water and sanitation protocols are not universally available around the world. The JOP was developed to provide a sustainable solution to this crisis as it is still plaguing our planet. The pilot project took place in Dakar, Senegal and helped to distribute clean

[1] This section was written collaboratively in order to comply with direct and specific requirements of Professor Anderson of the Chemical Engineering Department

drinking water to 100,000-200,000 people (Sanders, 2018). This system, to put it simply, takes human waste and turns it into clean drinking water.

The idea of deriving drinking water from human waste is not novel. For example, treatment facilities in the United States, as well as Singapore, have long been turning sewage into clean water that is safe for human consumption (Poon, 2015). However, in these cases, most of the recycled water does not go directly into the water supply. Instead, it is injected into the ground and mixed with groundwater before it is pumped out (Poon, 2015). Before the JOP, this Omni Processor technology had never been used for a sustainable sanitation initiative. There was no incentive for engineers in developed countries to move the technologies to sanitation facilities where they are not financially feasible (Cashman, 2020). Modern sewage plants do not have the same efficiencies as the JOP. Other plants usually burn waste by using diesel, and therefore consume a copious amount of energy (Chowdhry, 2015). By contrast, the JOP uses a steam engine which can produce more than enough energy to power itself and provide spare electricity.

The JOP technology has the ability to treat increasing amounts of city sewage through scale-up and process optimization. Scaling the JOP up for larger use will provide clean water, sustainable energy, and improve the living conditions of millions of people. The following is a description of the JOP which provides drinking water, electricity, and fertilizing ash in one system. The goal of this project is to determine the amount of drinking water, and power that will be produced through using human waste as the input. This system will be scaled up to be implemented in cities beyond Dakar, Senegal, where it currently only serves around 100,000 people, and analyze it to determine the sustainable in an under-developed city of approximately 1,000,000 people.

The JOP process entails water treatment/purification, electric power generation, and fertilizer ash production as shown in Figure 1. To produce drinking water, steam from the wet biosolids, or the human waste, is condensed into water and heavily filtered. For the filtration step at the end of the downstream process, we will be utilizing an RO membrane. RO forces water through a semipermeable membrane filled with pores of very small diameters which ensure full filtration of unwanted debris (Shenvi et. Al, 2015). To produce electric power, recycled water is put through a steam engine which is then placed into a generator that converts the steam into usable energy. This

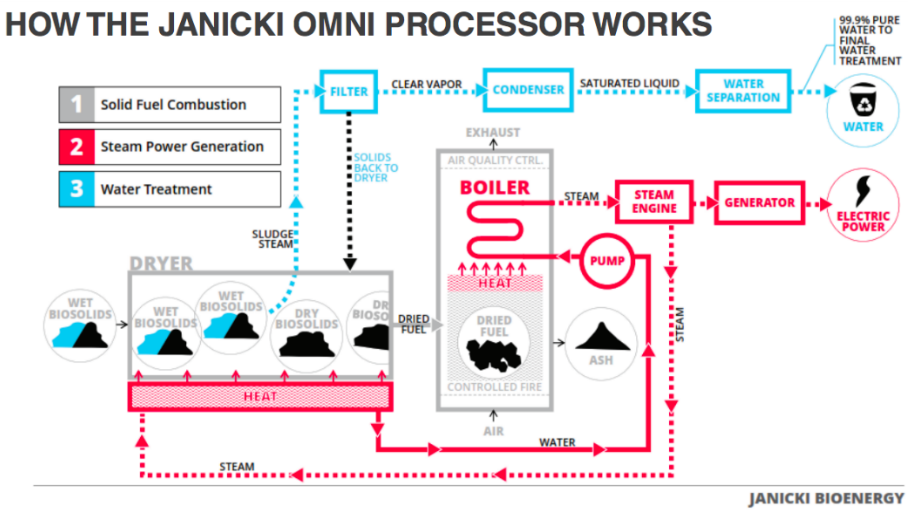

Figure 1. *A process flow diagram for the JOP (Cashman, 2020)*

power can then be funneled back into the process to perpetuate the cycle. As a side product, fertilizing ash is produced from drying and passing the waste through an incinerator. The scaled-up parameters will be determined through Aspen Plus, a software which allows us to simulate chemical processes, with known and unknown input variables. We will be using cost-analysis and our results from our simulation to determine if this system truly is sustainable and worth adopting in several locations around the world where necessary.

STS Problem

The West Point Treatment Plant, located in Seattle, Washington, is the largest water treatment plant in the Pacific Northwest (Long, 2018). On February 9th, 2017, this plant suffered a major failure thus significantly affecting the community surrounding it. Due to a large rainstorm, power went out to two sets of pumps that discharge treated wastewater into Puget

Sound (CBS News [CBS], 2017). Crews worked fast to divert the flows to bypass the plant and go directly into the sound, but the flooding damage was done and caused major destruction to the plant (Long, 2018). It dumped an estimated 235 million gallons of untreated wastewater — including 30 million gallons of raw sewage and hundreds of tons of partially treated solids at a nearby beach (Willmsen, 2017).

While the rain did exacerbate the electrical failure, it was an uncontrollable actor. The causes of this failure can be pointed to a key technical issue: the float switches. Float switches designed to detect high water levels inside the tanks failed to activate, allowing water to top over and flood surrounding areas (CBS, 2017). It was an inexpensive piece of equipment; when these devices repeatedly clogged, jammed, and failed in the past, employees bent the rod back in place instead of replacing them (Willmsen, 2017). Had they worked, the employees could have shut off the influent pumps that pumped raw sewage into the plant, ultimately saving the plant.

Though the failure of the float switches is to blame for the incident, this view overlooks the other actors that caused the project to fail. The Washington Department of Ecology's (DOE) investigation of this failure determined that inadequate maintenance, reliability issues and lack of employee training led to the plant's damage (Willmsen, 2017). This incident was the first in 14 years for the plant, as they were previously touted for their ability to stay within protocol (Long, 2018). This sense of complacency in the workplace allowed employees to bypass the rules and come up with inefficient quick fixes to technical problems. The weak safety culture of the plant eventually propelled the employees to treat the float switches as an unnecessary device by bending them and not replacing them. Therefore, the employees are not given the adequate training for troubleshooting, even for day-to-day tasks.

If we believe that only technical aspects were responsible for the project's failure, we will not understand the role other actors played alongside it in the plant failure. Understanding the root cause of lack of precautions and safety culture, and how lightly employees may take these things in a plant facility, is the key to coming to an appropriate response to similar incidents. Hazardous waste sites are known to be disproportionately located in nonwhite and poor communities (Erickson, 2016). After this failure, the communities surrounding this facility are now greatly impacted by the release of waste in their neighborhoods. Since the plant was destroyed, the people relying on this will be without a functioning wastewater plant for months. Not only will these communities suffer the effects of it, but it will affect their already, arguably, unstable lives.

I argue that it was the failure of the inexpensive float switches in conjunction with poor plant safety culture and lack of employee training that caused the project to fail. My analysis of the West Point Treatment Plant project as a failed incident to learn about the innerworkings of a system draws on the science, technology, and society (STS) concept of actor-network theory. This theory analyzes the power dynamics among human and non-human actors that come together in a network designed to accomplish a particular goal (Cressman). The network builder (one that recruits heterogenous actors to accomplish a goal) in this scenario is the West Point Treatment Plant. This builder recruited actors, like supervisors, employees, float switches, and alarms, to establish the safety of a stable treatment plant, or led to a lack thereof (Cressman). To support my argument, I will analyze evidence from the DOE's investigation of the incident, which provide safety culture protocols in reference to the actors in question.

Conclusion

The technical report will deliver a framework for a scaled-up JOP system to be used in an underdeveloped city of around a million people to provide clean drinking water. The report will provide estimations of amount of water produced, power produced, as well as a cost-benefit analysis to decipher the affordability. The STS research paper will provide further insight into the actor-network theory by analyzing the failure of the West Point Wastewater plant due to various technical and social actors in the plant operation.

The results of the technical report will aid in addressing the ability for a wastewater system to be sustainable and serve millions of people with clean water and better sanitation. It will provide a solution to this problem by outlining the means by which drinking water can be produced. In conjunction, the STS paper helps to broaden understanding of how the various actors truly affect the longevity and safety of a successful wastewater plant.

Word Count: 1922

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