Prospectus

Point-of-Use Water Treatment Device
(Technical Topic)

Theory of Technological Politics and the Disparity in Access to Improved Water Sources
(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

In Sub-Saharan Africa, less than 50 percent of the population uses an improved drinking water source, and many of them do not have access to water in close proximity to where they live. As a result, in many rural areas, women (64%) and girls (8%) spend more than 30 minutes each day making one water collection round trip and often have to make more than one trip per day ("Drinking water equity, safety and sustainability," 2011). The unreliable supply of safe drinking water increases the spread of water-borne diseases and leads to a lack of good hygiene practices, resulting in detrimental health effects. Additionally, due to the limited access to water, many of the rural communities resort to collection of water from wells, rivers, lakes, and rainwater harvesting and store the water in buckets and containers in the household, increasing the risk of contamination.

The Limpopo province in South Africa ranks among the lowest areas with access to clean drinking water. Although many of the villages receive water from municipal sources, the system provides intermittent service or, at times, no service at all. As a result, residents rely on community installed and operated distribution systems or nearby rivers to fulfill their water needs (Edokpayi et al., 2018). However, the alternative sources are often susceptible to point and non-point pollution and are frequently contaminated by fecal matter (Bain et al., 2014).

Consequently, in order to improve the quality of water that poor, rural residents consume, my team is designing a point-of-use (POU) water treatment technology that will allow households to treat water in the home shortly before consumption. However, a technical solution alone will not resolve the problem, as it does not account for the ways that power relations have shaped which areas, urban or rural, have access to a piped water supply. The political implications and social consequences must be considered with the development of the technologies in order to remedy the inequality in access to improved drinking water.

Therefore, to combat the water access disparities, both the technical and social aspects of the problem must be addressed. In what follows, I describe the development process for creating such a water treatment device. Then, I use the STS framework of technological politics to elaborate how the water distribution infrastructure, whether intentionally or unintentionally, advantages wealthy urban white areas and marginalizes poor rural black areas.

Technical Problem

In 2011, the World Health Organization predicted that by 2015, 672 million people would still lack access to improved drinking water sources, and many hundreds of millions more would not have sustainable access to safe drinking water. Although the estimate has improved from 884 million in 2008, the number is still far too high ("Drinking water equity, safety and sustainability," 2011). The area of Thohoyandou, in Limpopo Province, South Africa, lacks access to an improved water source, which leaves individuals vulnerable to the effects of water-borne diseases such as typhoid and cholera. These diseases are especially dangerous to children, as they often cause severe diarrhea which kills about 2.2 million people annually; 90% of these deaths are children ("WHO world water day report," n.d.).

Point-of-use water treatment technologies are an effective solution to combat water-borne illnesses and are currently employed in many households in Thohoyandou. The technologies are not reliant on state or community-run water infrastructure and allow for households to treat water in their own home shortly before consumption. Ionic silver has been known to have antimicrobial properties since Roman times, and recent studies have confirmed the efficacy of ionic silver for disinfection of potable water ("Silver as a drinking-water disinfectant," n.d.).

Currently, ionic silver is employed in several point of use water treatment technologies, including the Folia Water paper filter and the MadiDrop+ ("The Madidrop: Product information," 2017; Ehdaie et al., 2017).

The MadiDrop+ is a micro-porous, water permeable ceramic tablet infused with microscopic silver clusters. When placed in 10-20 liters of water, the tablet continually releases low level of silver ions, disinfecting many different pathogenic waterborne bacteria. However, the MadiDrop+ and other silver-based point of use water filtration systems do not regulate the amount of silver released into water and do not effectively oxidize the silver for disinfection. As a result, end users consume some of the silver in metal form, and only a fraction of the silver directly contributes to the disinfection. Consequently, the water is not properly sterilized and does not abide by the EPA secondary drinking water safety standard of 100 µg/L, which increases the risk of water-borne diseases ("Secondary drinking water standards: Guidance for nuisance chemicals," 2017). Therefore, my team is designing an electronic POU water treatment device that will control the number of silver ions released using an MSP430 microcontroller. The target concentration of ions delivered for the prototype is 50 µg/L, which is half of the EPA guideline. By limiting the device to operate only twice per day, we will ensure the amount of silver released stays within the 100 µg/L standard.

While these goals are a step in the right direction, the system we design must work outside the lab and be able to operate within its users' daily lives. Since most of the people within the town of Thohoyandou, South Africa are illiterate, the user interface will need to be extremely simple and cannot require any written instructions. Additionally, in order to be a viable solution for providing clean water in rural communities, the device will need to be extremely durable. Its enclosure must be able to withstand accidental drops and total immersion in water. Further, the device will be simple to use, relatively inexpensive, and power efficient.

STS Problem

In 1996 under Nelson Mandela's rule, South Africa wrote into its constitution the mandate guaranteeing access to sufficient food and water as a basic right. The new promise of access to water marked the end of forty-six years of harsh segregation under apartheid law and brought hope to the rural black population (Piper, 2014). Today, however, South African residents still do not receive equal access to water.

According to the South Africa Living Conditions Survey 2014/2015, more than 70% of people received piped tap water from water supply infrastructure within their household or yard, and 83% of people received water from a municipal water service provider (Akinyemi, 2018). While infrastructure exists across the country, providing potable water to households, the quality of service and operation varies tremendously amongst the provinces. Across Western Cape, an urban wealthy white province, 96% of households received consistent access to municipally provided tap water, whereas 66% of households received intermittent municipal water service in Limpopo, a poor rural black province (Akinyemi, 2018). The municipal service in Limpopo provides water to the communities on a scheduled service depending on the season, ranging typically from two to four days per week during the wet season and at most two days per week during the dry season (Edokpayi et al., 2018). The poor quality and maintenance of the water distribution infrastructure extending to these communities requires the frequent need for repair, during which time the municipal water service ceases completely. Therefore, although the water distribution system does technical work to provide households with safe drinking water, it also does significant social and political work.

If we continue to think that the water delivery technology only performs technical work, we will miss how it functions to advantage the wealthy, white, ruling class and marginalize the poor, blacks in South Africa. Drawing on technological politics, I argue that the employment of water distribution systems expresses and shapes power relations by privileging some and disenfranchises others based on socioeconomic status and geographic locations. Landon Winner's Theory of Technological Politics describes the ability of technology to "embody specific forms of power and authority" and whether intentionally or unintentionally, reflect and reify social relations of power and privilege (Winner, 1980).

Specifically, I will analyze how the water supply infrastructure in South Africa both privileges and deprives certain people based on a variety of demographics. The access to water and the benefits of its use privilege those with access to land and political and economic power. Thus, the water delivery technology in South Africa creates a political and social divide between those who can afford and have access to water distribution networks and those who do not.

Conclusion

In this paper, the technical and social solutions address an improved point-of-use water technology used by residents in Thohoyandou, South Africa and highlight the way in which the access to water infrastructure in South Africa both privileges and marginalizes certain populations based on various demographics. My team proposes the design of a new point-of-use water treatment device that improves upon existing technologies by regulating the amount of silver ion release to within the World Health Organization secondary drinking water safety standard. The device will require minimal user input and be power saving and affordable. In addition, the STS research paper will seek to explore the critical issue of access to water distribution networks in South Africa. Drawing on technological politics, I will analyze the way in which the distribution and operation of water delivery systems advantage the urban wealthy white communities and disenfranchise poor rural black communities in South Africa.

The results of both the technical and STS report will help to resolve the overall socio-technical problem of the lack of access to improved drinking water sources in South Africa. They will ultimately help to improve hygiene amongst the population and reduce the spread of water born disease. Without the insight that technology has the inherent capability of shaping power relations, equality of water distribution will not be attainable.

References

Akinyemi, B. E. (2018, April 26). Factors explaining household payment for potable water in South Africa. Retrieved October 21, 2019, from https://www.tandfonline.com/doi/full/10.1080/23311886.2018.1464379.

Bain, R., Cronk, R., Wright, J., Slaymaker, T., & Bartram, J. (2014, May 6). Fecal contamination of drinking-water in low- and middle-income countries: A systematic review and meta-analysis. Retrieved October 21, 2019, from https://journals.plos.org/plosmedicine/article?id=10.1371/journal.pmed.1001644.

Drinking water equity, safety and sustainability. (2011). Retrieved October 20, 2019, from https://data.unicef.org/resources/drinking-water-equity-safety-and-sustainability-2011-thematic-report/.

Edokpayi, J. N., Rogawski, E. T., Kahler, D. M., Hill, C. L., Reynolds, C., Nyathi, E., … Dillingham, R. (2018, February 7). Challenges to sustainable safe drinking water: A case study of water quality and use across seasons in rural communities in Limpopo Province, South Africa. Retrieved October 21, 2019, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6310213/.

Ehdaie, B., Rento, C. T., Son, V., Turner, S., Samie, A., Dillingham, R. A., & Smith, J. A. (2017, January 17). Evaluation of a silver-embedded ceramic tablet as a primary and secondary point-of-use water purification technology in Limpopo Province, S. Africa. Retrieved October 20, 2019, from https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0169502.

Piper, K. (2014). *The price of thirst: global water inequality and the coming chaos*. Minneapolis, MN: University of Minnesota Press.

Secondary drinking water standards: Guidance for nuisance chemicals. (2017, March 8). Retrieved October 20, 2019, from https://www.epa.gov/dwstandardsregulations/secondary-drinking-water-standards-guidance-nuisance-chemicals.

Silver as a drinking-water disinfectant. (n.d.). Retrieved October 20, 2019, from https://www.who.int/water_sanitation_health/publications/silver-02032018.pdf?ua=1.

The Madidrop: Product information. (2017). Retrieved October 20, 2019, from https://static1.squarespace.com/static/5964fe93b3db2b9a83379b1c/t/597b93f4d1758e4dad2c83c4/1501271031033/ProductInformation2017.pdf.

WHO world water day report. (n.d.). Retrieved October 21, 2019, from https://www.who.int/water_sanitation_health/takingcharge.html.

Winner, L. (1980). Do artifacts have politics?, Daedalus 109(1), 121–136.