Improving the MadiDrop+ Tablet (Point of Use Water Technology) With the Application of Silver and Copper

(Technical Report)

Societal and Cultural Influences on the Uptake of Water Disinfection Technologies; a Case Study of California, Australia, and South Africa

(STS Paper)

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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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Prospectus

Introduction

Globally, one in three people do not have access to safe drinking water (World Health Organization, 2019b). Clean water is necessary for good health, and the lack of sanitary water throughout the world poses numerous health and safety risks; millions of people die each year from waterborne illnesses. When humans drink or use unclean water, they risk contracting life-threatening diseases. Escherichia coli, cholera, and typhoid fever are just a few of the many illnesses that dirty water can transmit. The effects of these diseases include dehydration, diarrhea, stomach pain, fever, fatigue, and even death (Lifewater, 2019).

Existing and developing water disinfection technologies help to solve this global issue. Different technologies are used in different regions of the world, as many societal factors contribute to the availability and acceptance of specific technologies. There are many existing societal expectations and infrastructure that stimulate pushback of treatment technologies within some cultures and communities and support its usage in others. From California, to Australia, to South Africa, differing social perspectives influence the usage of water disinfection technologies. While the proposed technologies in each region are technologically sound in providing clean water, residents in California and Australia showed resistance to using a “toilet-to-tap” treatment system and to passing a referendum to build a water reuse system, respectively (From Toilet to Tap: Drinking Recycled Waste Water, 2014; Hurlimanna & Dolnicar, 2010). Conversely, citizens in South Africa welcomed ceramic pots as an effective point-of-use treatment technology (Tyeryar, et al., 2010). The STS research will analyze these case studies through the lens of “social construction of technology,” as they each exemplify how society and culture influence the acceptance and use of technology (Klein & Kleinman, 2002).

The second proposed project involves improving the MadiDrop+ tablet, as well as understanding possible benefits of using copper for water disinfection. The MadiDrop+ is a micro porous, water permeable ceramic tablet that releases microscopic silver to deactivate bacteria. This point-of-use water disinfection technology is highly effective in killing waterborne bacterial pathogens and moderately effective to fight against pathogenic viruses, protozoa, and mosquito larvae (Silivhere Technologies, Inc.). Additionally, communities without access to piped water sometimes must rely on home water storages that attract mosquitoes. Mosquito larvae hatch when submerged in water, and because mosquitoes can spread vector-borne diseases, these communities are at high risk of contracting diseases. Copper has the potential to interact with silver and increase the effectiveness of water disinfection across a variety of pathogenic organisms. Therefore, the technical research will pursue the ideal MadiDrop+ configuration that effectively kills pathogens and mosquito larvae. Ultimately, the team will produce a technical deliverable comprised of an improved MadiDrop+ by successfully adding copper to the tablet, and a technical report of an analyzation of copper's benefits to silver and its ability to disinfect contaminated water.

Technical – Improving the MadiDrop+ Tablet (Point of Use Water Technology) With the Application of Silver and Copper

Globally, there are over two billion people experiencing water insecurity and water scarcity (World Health Organization, 2019b). Climate change, pollution, and increasing water consumption are only growing this water crisis, and the direct effects are most pressing in developing countries (World Wildlife Fund, n.d.). Fortunately, there are many existing water treatment technologies that are utilized to provide clean water, both at a community and state level, and at home. Some methods to combat such water insecurity include pretreatment and disinfection of water sources. Pretreatment includes storage and settlement, filtration, and aeration, while types of disinfection include boiling, chemical disinfection, and solar disinfection. These treatment methods are performed either municipally or by point of use water treatment (POUWT) technologies.

While there are many options of processes for water treatment, there are also many reasons why some of these methods are considered substandard in some cases. The treatment is expensive, large or invasive, slow working, not socially accepted, does not completely disinfect the water, has potential long term health impacts, or leaves an undesired odor, color, or taste to the water, are all reasons why water treatment options are insufficient for some people or societies (Zinn, et al., 2018). Further, pretreatment methods on their own are inadequate for inactivating pathogens, which is crucial in providing safe drinking water. Unfortunately, when a treatment system has any of these displeasing features, it sometimes leads to the treatment not being utilized for water disinfection.

The MadiDrop+ is a micro-porous ceramic tablet, embedded with microscopic silver clusters and used as a point of use water treatment solution (MadiDrop+, n.d.). This technology is a good option for water treatment for many reasons: it is highly effective, low cost, works for 12 months (with an unlimited shelf life), easy to use, small and portable, non-toxic, does not affect the water’s taste, smell, or color, and does not need electricity (MadiDrop+, n.d.).

The current model of the MadiDrop+ is soaked in a silver nitrate solution, followed by being fired in a kiln at high temperatures. The tablet works as a pathogenic disinfectant when it is placed in a bucket of water, where it releases silver ions into the water to deactivate pathogens.

The shortcomings of the current MadiDrop+, however, are that it only meets two of the three required WHO standards in order to be a recognized POUWT method. Additionally, while the MadiDrop+ is extremely effective in killing bacterial pathogens, it is only moderately effective against pathogenic viruses, protozoa, and mosquito larvae (MadiDrop+, n.d.). To improve the tablet's effectiveness, the goal of this technical project is to experimentally improve upon the MadiDrop+ through the integration of copper into the tablet. In doing so, there is potential for copper to work synergistically with the silver currently in place, thereby enhancing the MadiDrop+ and its abilities to provide clean drinking water globally. Copper and its additional benefits will be measured through various experiments, including monitoring its effects on the emergence rates of mosquito larvae, and its effects of bacterial removal in contaminated water. To conclude, the effects of silver acting alone, copper acting alone, and the combination of these two elements will be compared to advance the MadiDrop+, and access to clean, safe drinking water as a whole. As a deliverable, the team will compose a technical report of the findings related to copper's water disinfection effects, as well as an improved MadiDrop+ tablet containing copper particles.

STS – Societal and Cultural Influences on the Uptake of Water Disinfection Technologies; a Case Study of California, Australia, and South America

While there are ample technologies effective in providing clean drinking water, such as the MadiDrop+ tablet, there are still billions of people every year that do not have access to safely managed drinking water services. Therefore, over 100 million people rely on untreated surface water for all their water-related needs. This water is oftentimes contaminated, leading to the transmission of numerous diseases, including cholera, diarrhea, hepatitis A, and many more (World Health Organization, 2019a). These sicknesses can gravely impact someone's health, sometimes leading to death. In fact, over three million people die from water related diseases annually (Berman, 2009). Lack of access to clean water affects more than just someone's physical health; when people must spend extra time, money, and energy on getting drinking water, they are less able to manage other important life factors. Improved water sources reduce the associated risks of having to travel for water, improve overall health, which leads to higher school attendance, and decrease the associated costs of getting sick, which allows people to be more economically productive (World Health Organization, 2019a).

Many water sanitation technologies and systems have been created to combat the global water crisis and minimize the amount of people affected by lack of access to clean drinking water. The accessibility, uptake, and social perception of these systems, however, often dictate the level in which safe drinking water is secured within communities. Many water disinfection technologies exist, but it is crucial to apply them appropriately in differing societies for well-rounded success. Further, how do societal and cultural perspectives influence the uptake of certain water technologies?

Just as it is important for water disinfection systems to be technologically viable, it is also crucial for these technologies to be positively perceived and accepted from a social and cultural perspective. California's toilet to tap water disinfection system faced this issue. While the technology involved disinfects water to a level that exceeds both state and federal regulations, officials have struggled to overcome the "yuck factor" hurdle from the public (From Toilet to Tap: Drinking Recycled Waste Water, 2014). Disgust has been a popular response to this treatment system, as it reuses sewage water and disinfects it for drinking water. Through community meetings and tours of the facilities, transparency between the public and health officials, and consistency of providing clean water, California was able to successfully implement this technology to address their growing water problems (Harris-Lovett & Sedlak, 2019).

Some societies' apprehension is too prominent, however, that the pushback against treatment systems and technologies wins; this is what happened in Toowoomba, Australia, in 2006. When the city proposed a referendum to construct a water reuse system in response to their growing concern over the sustainability of their water supply, members of the community voted against it. Even though new water infrastructure was necessary to ensure access to clean, safe drinking water in the future, politics, biased and false information, and the media all played parts in discouraging people from supporting, and even understanding the need for, this proposal to pass (Hurlimanna & Dolnicar, 2010).

In Thohoyandou, in the Limpopo Province in South Africa, aligned communal expectations of a water treatment and the actual treatment technology itself allowed for ceramic water filters to be a reliable, well accepted technology in this society. The ceramic pots and filters satisfied the overall needs of the members of this community, as well as being effective in disinfecting their water, so the acceptance and take-up of this technology was substantial (Tyeryar, et al., 2010). While all the technologies in these case studies are technologically sound water treatments, some are accepted into their respective communities, and others are not, because of the social and cultural influences that exist in a society.

It is critical to understand the audience, or society, that would be using a proposed water disinfection technology, and specifically what they want and expect from the technology. The social construction of technology, or SCOT, argues that it is humans and society that determines and shapes technologies, rather than the other way around (Klein & Kleinman, 2002). This theory asserts that a technology's success should be analyzed through the societal factors of the technology. Further, it is best to understand a technology through the stakeholders, participants, and societies that give value and meaning to the technology, considering the groups included in and excluded from defining the technology's success or failure. SCOT applies in the case of acceptance or rejection of water treatment technologies in various communities. It is the cultural norms in place throughout varying societies that determine a technology's success, independent of how effective it is in actually treating contaminated water. Critics of this theory contend that viewing any scenario through the lens of SCOT is only seeing half the picture; just as society influences technology, technology can influence society, working simultaneously and interconnectedly. When analyzing California, Australia, and South Africa, however, the dominating forces are the societies, rather than the technologies, when dictating the outcome within each society with respect to water treatment access. The STS paper will argue that, specifically when a new technology is introduced into an establish society, the societies and cultures have the overarching power to decide the success and acceptance of water disinfection technologies within their communities.

Research Question and Methods

Research Question: How can society influence the respective community's acceptance of water disinfection technologies?

The research question will be answered through historical case studies of differing water technologies applied within different communities around the world. The "toilet-to-tap" system in California, the Water Future reuse water referendum in Toowoomba, Australia, and ceramic pots in Thohoyandou, South Africa will be analyzed through the lens of their successes or failures of implementation within their respective societies. These cases will be compared to understand how the societies and cultures govern the level of success of certain water technologies within their communities.

Policy analysis will also be utilized to understand how the political organizations and structures within each case study affect both the technologies themselves and society's acceptance of the respective technology. The analysis will conclude by discussing what factors of each society played a role in the uptake of the water disinfection technologies, and the importance of understanding these factors to secure safe drinking water within communities.

Conclusion

This paper includes an examination of the MadiDrop+ tablet, a point-of-use water disinfection tablet, as well as societal influences over the uptake of water disinfection technologies within different communities. The MadiDrop+ currently acts as a disinfectant against pathogens, by releasing silver ions into the water. The team will aim to understand the impacts of adding copper to the MadiDrop+ tablet to improve overall disinfection abilities. This will be measured by both its impact on the removal of pathogenic bacteria and on mosquito larvae kill off. Further, this paper dives into the investigation of cultural and societal influences on the utilization of various water disinfection technologies. While many water technologies are physically sound and effective in providing clean drinking water, the societies in which they are being implemented in affect their success, in terms of usage and acceptance within the given community. California, Australia, and South Africa will be analyzed to determine the societal factors of each area that guided the acceptance or rejection of different water treatment technologies.

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