River Treatment in Chennai: Utilizing Bioprocessing for Energy Production

The Response to Nestlé's Water Appropriation in California

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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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General research problem

How can equitable access to safe drinking water be improved?

Water scarcity is a significant problem that billions of people face worldwide. Mekonne and Hoekstra found that two thirds of the global population in 2016 suffered from water scarcity for one month of the year at minimum. Water is a necessity for survival. The demand has increased due to increasing global population, changing consumption patterns, and expansion of irrigated agriculture (Liu et. al, 2017). There is enough freshwater to meet the global demand of water, but mismanagement and corruption cause inefficient supply (UNESCO World Water Assessment Programme, 2006). The scarcity poses a significant threat to the sustainable growth of human society.

River Treatment in Chennai: Utilizing Bioprocessing for Energy Production

How may river water in Chennai be cost effectively treated to supply drinking water?

In the city of Chennai, India, the Cooum River holds high levels of contamination in the form of sewage, biological matter, industrial waste, nutrients, and heavy metals. This area of India also faces high levels of water scarcity. Our goal is to design a reverse osmosis (RO) water treatment plant that sources water from the Cooum river as an alternative source of drinking water for Chennai to relieve some of this water scarcity. Water will be directly pumped from the Cooum River and will go through various stages of pretreatment before RO treatment. These pretreatment steps will include sedimentation of large solids, a macro-filter, and a microfilter. This water will then be pumped through the RO membrane. The permeate water leaving RO will be disinfected and leave the system as potable water. Hydrothermal liquefaction (HTL) will be a secondary process that uses the biomass from the river to produce an energy rich bio-crude oil as a byproduct. We would like to join these processes together in a centralized system by using the

sludge streams produced in pretreatment of water as a feed for HTL and recycling the dirty water produced in HTL into our water treatment process. A simple process flow diagram can be seen in Figure 1, with more in depth illustration for HTL in Figure 2. The final products of this project will be clean drinking water and bio-crude oil.

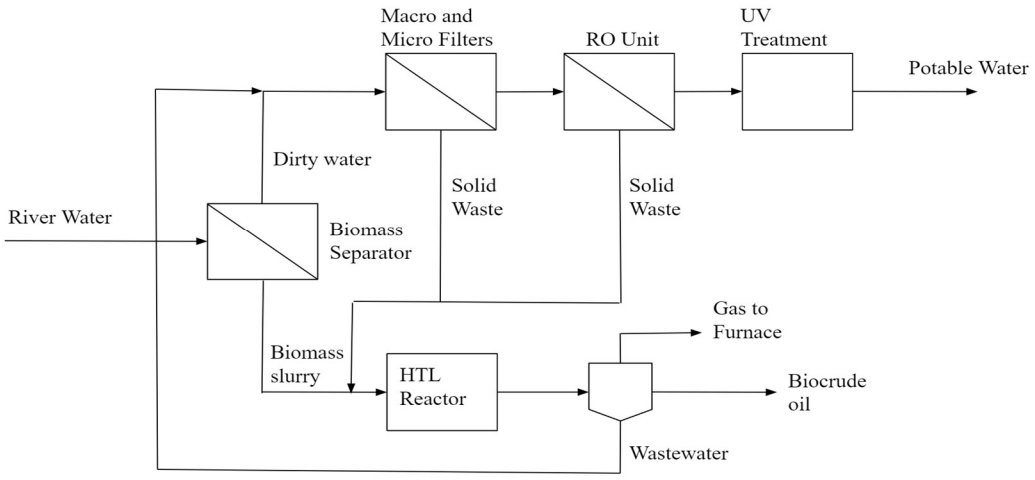

Figure 1: Overall process flow diagram (author).

Chennai gets most of its drinking water from the monsoon season, however when this season is short or does not provide enough rain, the city faces serious water scarcity. This is what occurred during the 2019 water crisis of Chennai (Frayer, 2019). The proposed design is worth pursuing as it addresses the problems of water scarcity in Chennai, as well as uses the pollution, specifically the excess of biomass, in the Cooum river as a profitable resource. RO will be used as a promising filtration technology to produce the potable water product. Additionally, HTL is a very new technology that has never been scaled up to larger than in-lab processes. However, industrially sized designs have been proposed, such as the design seen in Figure 2 (Snowden-Swan et. al., 2016). Scaling up HTL and connecting it with the RO process streams will be a significant challenge of this design project.

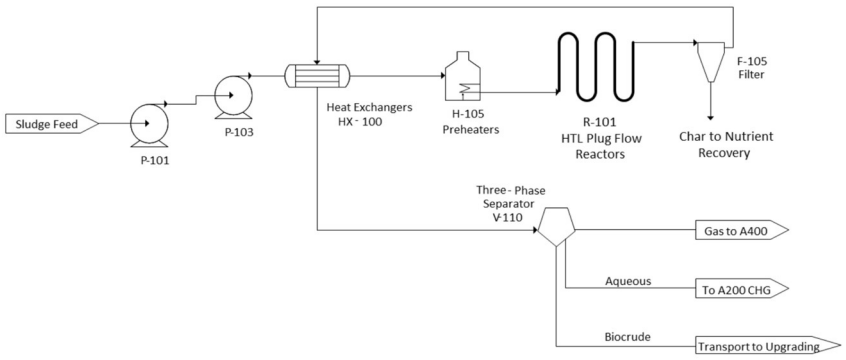

Figure 2. Hydrothermal liquefaction process flow diagram (author).

Information regarding the flow rates of pollutants in the Coum River will be obtained from sources that analyze the river for its contents to understand the components of the feed stream (Gowri et. al., 2007). The two-semester technical project will be done amongst a group of five individuals. Calculations will be done using shared Excel spreadsheets, dividing calculations amongst group members as needed. Every calculation will be checked by at least two team members before publishing. Where appropriate, Aspen Plus will be used to simulate certain processes to obtain stream data and thermodynamic properties in the process. The group will meet at least once a week to discuss progress, findings, and future calculations.

The Response to Nestle's Water Appropriation in California

How is the California State Water board responding to the unethical extraction of water by the Nestle Corporation?

California is enduring extended drought. Nestlé Water North America Inc. in California is taking water from Strawberry Creek in San Bernardino without paying for it, contributing to the state's drought (James, 2015). The company is jeopardizing area ecosystems and taking water from communities that need it. Opponents of the water grab have organized to stop it. The

California Water Board has led the response. Observing this response will provide a case for treating private corporation unethical extraction.

In collaborative governance, public and private stakeholders work with public agencies in decision making (Ansell & Gash, 2018). Collaborative governance was seen as an asset for environmental regulation over twenty years ago (Randolph & Bauer, 1999). Ansell & Gash identify variables that influence successful collaboration under collaborative governance, yet do not address how collaborative governance can be implemented. The California Water Board response can be used as a potential answer to this question.

Many participants of interest are to be analyzed. The California State Water Board is a state agency that regulates water extraction in the public interest (Rizzardo & Board, 2021; Stork et al., 2021). The board manages many programs to provide for, "A sustainable California made possible by clean water and water availability for both human uses and environmental resource protection." (Board, 2020).

Nestle Water North America Inc, renamed to BlueTriton in 2021, is a for-profit corporation that presents itself as an advocacy committed to a sustainable water supply (BlueTriton, 2021; Nestlé USA, 2016). The company claims to be "learning from what we have done in the past to better understand what is expected of us in the future" (BlueTriton, n.d.)

The U.S. Forest Service is a federal agency of the Department of Agriculture. It administers National Forests, including the San Bernardino National Forest (James, 2015). The service provides permits to watersheds, including the Strawberry Creek watershed in San Bernardino (Behrens, 2018).

The Story of Stuff Project (2020) is an advocacy seeking to restore public trust in water in the State of California. It claims "Nestle's operations…have left a legacy of broken promises,

ecological damage, and a lack of water access" (Story of Stuff Project, n.d.). The group filed complaints against the U.S. Forest Service to prohibit operation unless a valid permit was presented (Rizzardo & Board, 2021).

The *Desert Sun*, a daily newspaper based in Southern California and owned by Gannet Co. Inc broke the news on Nestle's unethical extraction (James, 2015).

References

Ansell, C., & Gash, A. (2008). Collaborative governance in theory and practice. *Journal of public administration research and theory*, *18*(4), 543-571. Web of Science.

Behrens, Z. (2018, June 27). Decision released for Nestle's permit request. United States Department of Agriculture Forest Service. https://www.fs.usda.gov/detail/sbnf/news-events/?cid=FSEPRD585224

BlueTriton. (2021, April 6). Nestle Waters North America Becomes BlueTriton Brands. BlueTriton. https://www.nestle-watersna.com/media/pressreleases/allpressreleases/nestle-waters-north-america-becomes-bluetriton-brands

BlueTriton. (n.d.). Spring Water Siting Framework. BlueTriton. https://www.nestle-watersna.com/communities/spring-water-sources/siting-framework

Frayer, L. (2019, July 18). The Water Crisis In Chennai, India: Who's To Blame And How Do You Fix It? NPR. https://www.npr.org/sections/goatsandsoda/2019/07/18/742688141/the-water-crisis-in-chennai-whos-to-blame-how-do-you-fix-it

Gowri, V. S., Ramachandran, S., Ramesh, R., Pramiladevi, I. R., & Krishnaveni, K. (2007). Application of GIS in the study of mass transport of pollutants by Adyar and Cooum Rivers in Chennai, Tamilnadu. *Environmental Monitoring and Assessment*, *138*(1-3), 41–49. https://doi.org/ 10.1007/s10661-007-9789-9.

James, I. (2015, December 2). Bottling water without scrutiny. *The Desert Sun*. https://www.desertsun.com/story/news/2015/03/05/bottling-water-california-drought/24389417/.

Liu, J., Yang, H., Gosling, S. N., Kummu, M., Flörke, M., Pfister, S., Hanasaki, N., Wada, Y., Zhang, X., Zheng, C., Alcamo, J., & Oki, T. (2017). Water scarcity assessments in the past, present, and future. *Earth's future*, *5*(6), 545-559.

Mekonnen, M. M., & Hoekstra, A. Y. (2016). Four billion people facing severe water scarcity. *Science advances*, *2*(2), e1500323.

Nestlé USA. (2016, May 6). Nestlé Waters North America Statement Regarding U.S. Forest Service Public Comment. Nestlé USA. https://www.nestleusa.com/ask-nestle/our-operations-in-the-san-bernardino-national-forest

Randolph, J., & Bauer, M. (1999). Improving environmental decision-making through collaborative methods. *Review of Policy Research*, *16*(3-4), 168-191. Wiley Online Library.

Rizzardo, J. & Board. (2021). Notice of revised report of investigation and draft cease and desist order for Nestle Waters North America, Inc. For unauthorized diversion and threatened unauthorized diversion from Strawberry Creek, San Bernardino County.

Snowden-Swan, L. J., Zhu, Y., Jones, S. B., Elliott, D. C., Schmidt, A. J., Hallen, R. T., Billing, J. M., Hart, T. R., Fox, S. P., & Maupin, G. D. (2016, June). Hydrothermal Liquefaction and Upgrading of Municipal Wastewater Treatment Plant Sludge: A Preliminary Techno-Economic Analysis (PNNL--25464). Pacific Northwest National Laboratory, U.S. Department of Energy. https://doi.org/10.2172/1258731

State Water Resources Control Board. (2020, November 25). About the Water Board. https://www.waterboards.ca.gov/about_us/

Stork, N., Vasquez, V., Eggers, T., & Petruzzelli, K., State Water Resources Control Board. (2021). *Revised Report of Investigation, INV 8217*.

Story of Stuff Project. (2020, October 19). Public Letter: Nestle's Troubled Water. https://www.storyofstuff.org/blog/public-letter-nestles-troubled-water/

Story of Stuff Project. (n.d.). Nestle's Troubled Waters. Story of Stuff Project. https://www.storyofstuff.org/unbottle-water/nestles-troubled-waters/

UNESCO World Water Assessment Programme. (2006). Water, a shared responsibility. The United Nations World Water Development Report 2.