Brewery Sustainability: Pollution Prevention Reducing Toxic Cleaners

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Abstract

The cleaning process and chemicals a brewer chooses vary widely from brewer to brewer and worksite to worksite; many factors contribute to the costs involved in this crucial and essential aspect of brewery operation. This is where us as Intern through the University of Southern Maine under the New England Environmental Finance Center grant project joins the process with the partnership of TURI. The Toxic Use Reduction Institute out of Lowell, Massachusetts in order to help discover less toxic cost-effective alternatives to the cleaning practices within a brewery.

In this partnership, we set out to create a less toxic money efficient chemical and sanitizer. Our goal is to design a mixture that will allow brewers to get the best possible clean without harming themselves or the environment and cut back on the amount of water used. Two solutions are made, the first is a detergent called catholyte, the second is a disinfectant called anolyte.

The goal of this process is to get a score of zero bacteria left in the tanks. After a few tests, we have come to the conclusion it is possible. We have gotten a level of zero, as well as half the amount of water used. This allows brewers to save money, water, and the environment one clean at a time. The financial benefit of using the ECA technology as proposed totals a saving in operational costs of $245 per month, or $2,940 per year (TURI, 2019). Costs in areas of chemicals, energy, and water use have been reduced.

Beer Making Process

Beer is a growing market in the world but specifically in New England.
The process to make beer is quite simple.

Step 1: Milling the grain
Beginning in the brewhouse, different types of malt are crushed together to break up the grain kernels in order to extract fermentable sugars to produce a milled product called grist.

Step 2: Mash conversion
The grist is then transferred into a mash tun, where it is mixed with heated water in a process called mash conversion. The conversion process uses natural enzymes in the malt to break the malt's starch down into sugars.

Step 3: Lautering
Where the mash is then pumped into the lauter tun, where a sweet liquid known as the wort is separated from the grain husks.

Step 4: Boil
The wort is then collected in a vessel called a kettle, where it is brought to a controlled boil before the hop is added.

Step 5:
The wort is separating and cooling. After boiling, the wort is transferred into a whirlpool for the wort separation stage. During this stage, any malt or hop particles are removed to leave a liquid that is ready to be cooled and fermented.

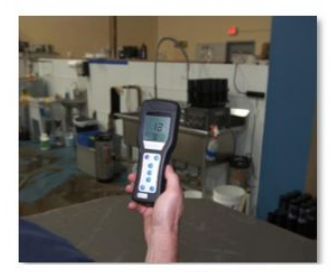
Step 6: Fermentation
The start of fermentation is once the yeast is added during the filling of the vessel. Yeast converts the sugary wort into beer by producing alcohol, a wide range of flavors, and carbon dioxide.

Step 7: Maturation
After fermentation, the young beer needs to be matured in order to allow both a full development of flavors and a smooth finish.

Step 8: Filtration, carbonation, and cellaring
After reaching its full potential, the beer is filtered, carbonated, and transferred to the bright beer tank, where it goes through a cellaring process that takes 3-4 weeks to complete.

Step 9: Once completed, the beer is ready to be packaged
Some beers will take longer than others in this process, it all depends on the style and profile of the beer that one will be drinking.

Picture Credits to Alan Bennett. (Left to Right, Cameron Reynolds USM, Jim Denz Island Dog Co-Owner Head Brewer, Kathleen Rattazzi USM)

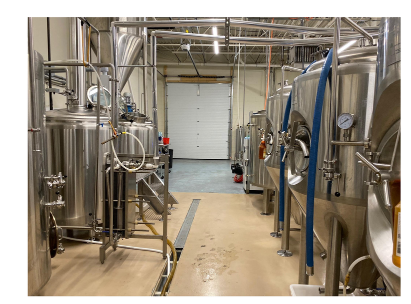


Demonstrating use of the ATP meter

Demonstrating swab preparation for off-site analysis

Demonstratina use of the NaDCC tablets

Adding sanitizer to the fermenter



Overview Summary			
Phase	***Function***	***Product & Ingredients***	***Characteristics***
Baseline	Detergent	PBW: 30% Sodium Metasilicate	pH 11-12
	Sanitizer	Saniclean: 29% phosphoric acid and 10% sulfonated oleic acid	pH 1
Phase I: Cleaning and Sanitization using ECA – large capacity	Detergent	Catholyte: weak sodium hydroxide	400 ppm NaOH pH >11.4
	Sanitizer	Anolyte: hypocholorous acid and sodium hypochlorite	190 ppm free available chlorine pH 6.8
Phase II: Cleaning and Sanitization using ECA – janitorial capacity	Detergent	Potassium carbonate mixture at <0.3%	pH 10-11
	Sanitizer	Acetic acid <2.5%	pH 2.75
Phase III: Sanitization with NaDCC tablets	Detergent	PBW: 30% Sodium Metasilicate	pH 11-12
	Sanitizer	NaDCC tablets generating hypochlorous acid	100-200 ppm free available chlorine

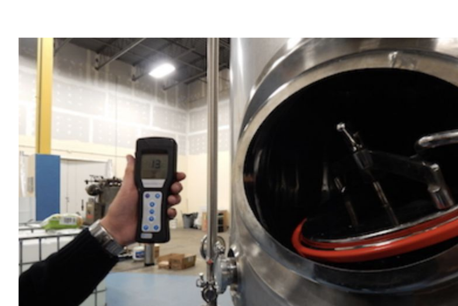
Baseline and Phase II ECA Testing Results									
Equipment/Stage	***Baseline 1***			***Baseline 2***			***Phase II ECA***		
	ATP	Colony Count[1]	CFU	ATP	Colony Count	CFU	ATP	Colony Count	CFU
Mashtun									
Upon emptying	11		ND						
After cleaning	254	GNR: 15 GPC: 2 GPR: 14	3100						
Brew Kettle									
After emptying	2		ND						
After rinsing	0		ND		GNR: 548[2]	548,000,000			
After acid						ND			
After cleaning	4		ND			ND			
After sanitizing						ND			
Fermenter									
After emptying	1259		ND						
After rinsing	223		ND	95		ND	8475		ND
Upon cleaning	32		ND	2		ND	155[3]		ND[4]
After sanitizing	2		ND	5		ND	3	GNR: 2	200

[1] GNR = gram-negative rods; GPC = gram-positive cocci; GPR = gram-positive rods.
[2] Kettle sat over the weekend before cleaning.
[3] Dropped to 0 after re-cleaned with 50/50 mix of ECA detergent and powdered brewers wash (original cleaner) at 130°F.
[4] Stayed at ND when sampled after 50/50 cleaning as noted in footnote 3.

The results of the testing are recorded in the table below:

NaDCC Tablet Results				
Sample Taken	***Date/Time***	***ATP[1]***	***Chlorine Meter[2]***	***Lab[3]***
After cleaning and rinsing	5/17/17, 11:30 AM	2	No alarm	None detected
After sanitizing	5/17/17, 11:40 AM	0	Alarm	None detected
After flush rinse	5/17/17, 11:52 AM	0	No alarm	None detected

[1] ATP reading of <10 is acceptable, <5 is preferred, and 0 is ideal
[2] Chlorine meter threshold is set to alarm at concentrations at or above 0.5 ppm.
[3] A bacterial count result of "none detected" is desirable.



Merrimack Ales During the testings

TURI LAB where all strips are tested

What's Next?

After you package the beer and place into bottles, kegs, and cans, you then need to clean all the equipment. The cleaning process and chemicals a brewer chooses vary widely from brewer to brewer and worksite to worksite; many factors contribute to the costs involved in this very important and essential aspect of brewery operation. Many brewers have their personal preference but how do they gain the knowledge of their preference? After asking a handful of brewers they say they first start by learning what other brewers use to clean. Some brewers go with what's cheapest and others go with what brands get the job done.

TURI Partnership and Testing

This is where us as Intern through the University of Southern Maine under the New England Environmental Finance Center grant project joins the process creating a partnership with the Toxic Use Reduction Institute out of Lowell Massachusetts in order to help discover less toxic cost-effective alternatives to the cleaning practices within a brewery. The Toxics Use Reduction Institute provides resources and tools to help businesses, municipalities, and communities in Massachusetts find safer alternatives to toxic chemicals (TURI, 2020).

In this partnership, we set out to create a less toxic money efficient chemical and sanitizer. The test that we have created to do has been designed by TURI. TURI created stainless steel plates that will be used to test different sanitizers and chemicals. Our goal is to design a mixture that will allow brewers to get the best possible clean without harming themselves or the environment and cut back on the amount of water used. Two solutions are made, the first is a detergent called catholyte, which is a weak sodium hydrate solution of approximately 400 ppm and with a pH of greater than 11.4. The second is a disinfectant called anolyte, which is a hypochlorous acid and sodium mixture with a pH of 6.8. The anolyte has 190 ppm of free available chlorine (TURI, 2019).

While we as interns were brewing with head brewer Jim from Island Dog we decided that taking 5 gallons of sludge back to the lab would be more effective to test rather than putting 98 plates into the brew kettles. Once we brought the 98 plates back to the lab with 5 gallons of sludge we then recreated the brewing process to allow us to get the full potential out of this trial. A few tests of the cleaning product has been done. TURI allows for small businesses in Massachusetts to get $10,000 grants. These grants then allow them to further their businesses in any way possible. Merrimack Ales in Lowell has joined to test how well electrochemical activation (ECA) technology works for cleaning and sanitizing equipment.

This test will show the technology could eliminate or greatly reduce, caustic sodium hydroxide and acids used for cleaning and the follow on products used for sanitation. The goal of this process is to get a score of zero bacteria left in the tanks. After a few tests, we have come to the conclusion it is possible. We have gotten a level of zero, as well as half the amount of water used. This allows brewers to save money, water, and the environment one clean at a time. The financial benefit of using the ECA technology as proposed totals a saving in operational costs of $245 per month, or $2,940 per year (TURI, 2019). Costs in areas of chemicals, energy, and water use have been reduced.

Based on the testing results obtained during this phase of the project, the brewery is confident about moving to the NaDCC tablets for their sanitization process.

References

[1] Maine Department of Environmental Protection. (2019). *Sustainability.* Retrieved from, https://www.maine.gov/dep/sustainability/index.html.
[2] Toxics Use Reduction Institute. (2020) Making Massachusetts a Safer Place to Live and Work. Retrieved from, turi.org.
[3] Toxics Use Reduction Institute. (2019) Microbrewery Tests Less Hazardous Cleaning and Sanitizing Technology, turi.org.

Acknowledgements

A huge thank you goes out to the U.S. Environmental Protection Agency, New England Environmental Finance Center, Maine Department of Environmental Protection, Toxic Use Reduction Institute, and especially our Maine Craft Breweries! Thank you Cameron Reynolds for your contribution on our internship; thank you Martha Sheils, Professor Peter Cooke, and Dr. Sara Ghezzi for mentoring Cameron and I through this project; thank you U.S. Environmental Protection Agency for the Pollution Prevention (2018-2021) and Healthy Communities (2019-2021) grant funds that supported this project.