GTA BREWS
HOMEBREW CLUB

Intro to Brewing Water 2.2

Turning a dry subject… wet

GTA Brews – January 2019

Past Presentations

- gtabrews.ca/presentations

Presentations from Club Meetings

October 2018: Build A Brewery by Kyle Smith
September 2018: Introduction to Basic Micro
July 2018: Building a Destination Brewery
June 2018: John's Journey to Folly
April 2018: Craft Malting with Barn Owl Malt
April 2018: Kettle Souring with Rouge River Brewing
March 2018: Hop Farming in Ontario
Feb 2018: Introduction to Mixed Culture Brewing
January 2018: Intro to Brewing Water 2.1
October 2017: Saison – A Brewer's Blank Canvas by Peter Caira
September 2017: How to Win @ Homebrew Competitions
August 2017: Harvesting Wild Yeast by Richard Priess
July 2017: Adding Wood to Beer
May 2017: Tiny Bubbles – Beer Carbonation Primer
March 2017: Mini RIMS
February 2017: Kveik
January 2017: Intro to Brewing Water 2
June 2016: Off Flavours in Beer | PPT
May 2016: Belgian Sour Beers
April 2016: Small Space Brewing
March 2016: Grain to Glass with Eric
January 2016: Intro to BJCP 2015 Guidelines | PPT
September 2015: Finishing Beer
September 2015: How To Enter a Competition
January 2015: Intro to Brewing Water

Topics Covered

- Does Water Chemistry Matter?
- Removing Chlorine
- Intro to Brewing Minerals
- Water Sources
- Intro to Mash pH
- Tools Needed
- My Approach (& Examples)

Does Water Chemistry Matter?

- Yes… but only from good beer to great beer
- Master these things first to make good beer:
  - Fermentation and yeast health
  - Packaging and sanitation
- Beer is 95% water
- Water composition influences flavour expression and certain yeast behaviour
- Brulosophy water XBMTs have been significant

Does Water Chemistry Matter?

- “Water Chemistry” is a vague term
- Refers to combination of:
  - Mash pH adjustment
  - Mineral concentration adjustment

Removing Chlorine

- Chlorine/Chloramine is added by the city to disinfect tap water
  - Remove from brewing water to avoid off-flavours
- These compounds react with yeast-derived phenols to form Chlorophenols
  - Flavour: medicinal, bleach, antiseptic mouthwash
- Method 1: Campden tablet addition
  - Comes in both Sodium and Potassium versions
  - 1 tablet treats up to 20 gal water (adds 9 ppm SO4)

Removing Chlorine

- Method 2: Activated carbon filtration
  - Bonus of also removing other solids like pesticides
  - Palmer recommends a flow of rate of <1 gal/min
- Eric's Recommendation for Homebrewers:
  - Use Method 1: potassium campden tablets
    - Simpler than watching GAC filter flow rate
  - Add 1 tablet into strike water
    - No need to split between strike and sparge water
    - Round up to the nearest tablet

Intro to Brewing Minerals

- Common brewing minerals
  - Cations: **Calcium (Ca)**, Magnesium (Mg), and Sodium (Na)
  - Anions: Bicarbonate (HCO_3), **Sulfate (SO_4)**, and **Chloride (Cl)**
- Calcium (Ca) affects “everything”
  - Lowers mash pH
  - Promotes flocculation of yeast and protein
  - Limits extraction of tannins (astringency)

Intro to Brewing Minerals

- Usually Calcium (Ca) is added as gypsum ($CaSO_4$) and/or Calcium Chloride (CaCl)
- Sulfate (SO_4) affects perception of bitterness
  - Helps give the beer a drier and crisper impression.
- Chloride (Cl) affects perception of sweetness and body
  - CaCl can pick up moisture causing you to add less
    - Consider drying in the oven to make it Anhydrous again
  - Recommended to mix up a solution

Intro to Brewing Minerals

- Choose ratio (SO_4:Cl) for desired result
  - "Seasoning level" matters
  - Experiment to find your preference
- Bicarbonate (HCO_3) helps determine alkalinity
  - Acts as a buffer working against acid additions
  - Can be good to balance against acidic malt
- Magnesium (Mg) and Sodium (Na)
  - Usually you don't aim to adjust these
  - Track them to make sure they are in range

Intro to Brewing Minerals

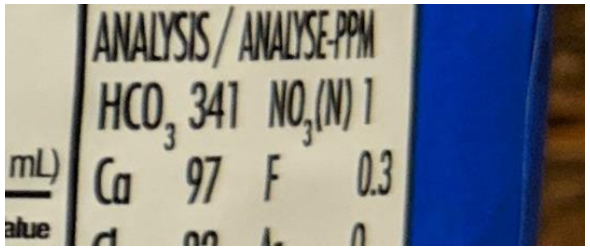
- Calcium (Ca) 50-150 ppm
  - Less than this is okay for lagers
- Sulfate (SO_4) 0-400 ppm
  - More than this becomes harsh and astringent
- Chloride (Cl) 10-200 ppm
  - Mostly <50 ppm, especially with high sulfate
  - Notably NEIPA goes up to 200 ppm
- Bicarbonate (HCO_3) <50 ppm
  - May need acid or acidic malt to achieve this

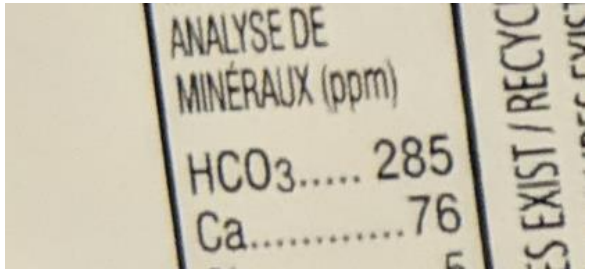
Water Sources

- Toronto Tap Water - gtabrews.ca/toronto-water-profile
  - Calcium (Ca) - 35 ppm
    - Note that this is <50 ppm
  - Chloride (Cl) - 27 ppm
  - Sulfate (SO_4) - 27 ppm
  - Total Alkalinity - 86 ppm
    - Converts to ~104 HCO_3
  - Magnesium (Mg) - 9 ppm
  - Sodium (Na) - 14 ppm

Water Sources

- Bottled Water
  - Don't use bottled "spring" water in Ontario
  - Most is very high in alkalinity (HCO_3)





- Softened Water
  - Uses salt (NaCl or KCl) to remove hardness (Ca & Mg)
  - Adds significant amounts of Sodium or Potassium
  - Avoid using softened water for brewing
    - Buy RO water instead

Intro to Mash pH

- Briefly, pH is:
  - Concentration of H+ ions using exponential scale
  - Less is acidic, more is basic (aka. alkaline)
  - 7.0 pH is middle of the range
- Tap water is usually around 6.8 - 7.8 pH
  - Drops when you add grain, salts, or acid
- Mash pH should be 5.2 – ~5.6 pH
- Beer pH is usually 4.0 – 4.4 pH

Intro to Mash pH

- With mash pH in range:
  - Hop bitterness is more pleasant and doesn't linger
  - Improved break formation
  - Enzymatic activity in the mash is increased
  - Beer is crisper, fresher, and shows more character
- Always measured at room temp (~20°C)
  - pH reads 0.2 - 0.35 pH lower at mash temp
  - ATC compensates for probe, not mash chemistry
- Read this Braukaiser.com post for more detail

Intro to Mash pH

- Balancing act between
  - Alkaline: water
  - Acidic: malts, added salts, and acid additions
- Highly alkaline water needs additional acidic additions (usually more lactic acid)
- Thinner mash usually means higher pH
- Calcium has a limited effect on mash pH
- Roast and crystal malts are more acidic

Tools Needed

- pH Meter
  - General Specs:
    - Reliable brand with available & affordable probes
    - 0.01 or 0.05 pH accuracy, 0.01 pH resolution
  - Recommended: Thermoworks 8689 ($85 USD)
    - Brulosophy Review
    - Used to recommend Omega PHH-7011 ($101 -> $158)
  - pH meters recommended by Americans (Milk the Funk) don't have probes available in Canada
    - Milwaukee MW102, Hach Pocket Pro+

Tools Needed

- Accurate scale with 0.01 g resolution
  - Recommended: Smart Weigh Top500
- Salts and acid
  - Lactic acid 88%
  - Gypsum ($CaSO_4$) & Calcium Chloride (CaCl)
- Metal cup
  - Used to cool pH samples to room temp
- DO NOT USE: 5.2 Stabilizer or pH strips

My Approach

- Pick your software
  - Bru'n Water v5.5, Brewer's Friend, Beersmith 3
  - I use Bru'n Water
- Decide on a mineral profile
  - More than 50 ppm Calcium
  - High sulfate for hoppy/bitter beers (SO_4:Cl > 2)
  - Start balanced for most beers (SO_4:Cl ~ 1.3)
  - More chloride for sweet/malty beers (SO_4:Cl < 0.5)

My Approach

- Start off with preset profiles (Eg. Yellow Dry)
  - Use colour and flavour balance
- Avoid historical water profiles
  - Most breweries treated their water
- Add enough acid to hit desired mash pH
- Avoid adding alkalinity in dark beers by mashing thinner
  - Opt for Pickling Lime ($Ca(OH)_3$) over Chalk ($CaCO_3$) if you need to add alkalinity, chalk doesn't dissolve

My Approach

- Use lactic acid instead of acid malt
  - Phosphoric works great if you can get it
- I aim every beer at 5.2 pH, but accept anything under 5.4 pH
  - Some prefer to aim darker beer at 5.4 - 5.6 pH
- Adjust after measuring actual mash pH
  - Model doesn't account for differences between different grains with same colour
  - Usually this means adding more acid

My Approach

- Rule of Thumb:
  - Add 1 - 1.5 mL of 88% lactic acid per 0.1 pH point above desired mash pH
  - Assuming: 5 gal batch using Toronto tap water
- Example Mash pH Adjustment:
  - Expected 5.20 pH, Measured 5.45 pH
  - Add ~3 mL of lactic acid
  - Re-measured 5.26 pH
- Reflect this into your recipe for next time

Bru'n Water Setup (Toronto)

Water Report Input

Hover cursor over cells w/ red corner marks to display information

Cations	Enter Ion Concentrations from Water Report (mg/L or ppm)		Anions
Calcium (Ca)	35.1	103.9	Bicarbonate (HCO_3)
Magnesium (Mg)	9.0	0.1	Carbonate (CO_3)
Sodium (Na)	13.7	26.5	Sulfate (SO_4)
		26.6	Chloride (Cl)
Optional Inputs (not required, but may improve ion balance)		0.0	Nitrate (NO_3)
Potassium (K)	0.0	0.0	Nitrite (NO_2)
Iron (Fe)	0.0	0.0	Fluoride (F)

If water report provides only **Total Alkalinity** or **Temporary Hardness** (as $CaCO_3$), use the calculator below to estimate the Bicarbonate and Carbonate concentrations. Insert the estimated Bicarbonate and Carbonate results in the table above.

Reported Total Alkalinity or Temporary Hardness (as CaCO3) (mg/L or ppm)	Reported or Measured Water pH	Estimated Bicarbonate Concentration (ppm)	Estimated Carbonate Concentration (ppm)
85.5	7.6	103.9	0.2

Example 1. American Porter

Grain Bill Input

Hover cursor over cells w/ red corner marks to display helpful information

Grains	Grain Type	Quantity (lb)	Quantity (oz)	Color (L)	Percentage of Grain Bill
Maris Otter	Base Malt	9.0	0.0	3.5	70.6
Munich I	Base Malt	1.5	0.0	6.5	11.8
Crystal II	Crystal Malt	0.0	14.0	65	6.9
Chocolate Malt	Roast Malt	0.0	12.0	450	5.9
Black Patent	Roast Malt	0.0	10.0	550	4.9
	Base Malt	0.0	0.0	0	0.0

Water Profile Adjustment Calculator

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Desired Water Profile	Calcium (ppm)	Magnesium (ppm)	Sodium (ppm)	Sulfate (ppm)	Chloride (ppm)	Bicarbonate (ppm)
Black Full	50	5	33	35	45	140
Existing Water Profile	36	9	14	26	25	107

Water Additions

Minerals	Addition (gram/gal)
Gypsum ($CaSO_4 \times 2H_2O$)	0.10
Calcium Chloride ($CaCl_2$)	0.20

Example 1. American Porter

Actual Finished Water Adjustment (ppm)	25	0	0	15	34	0						Finished SO_4/Cl Ratio
Mashing Water Profile	61	9	14	41	59	107						0.7
Overall Finished Water Profile	61	9	14	41	59	NA						
							Total Water Additions				Total Batch Volume	
Estimated Mash pH	5.17	This pH value is NOT VALID until the grain information is properly entered for the beer on the **Grain Bill Input** sheet.					Mash		Sparge			
Water Additions							Water Volume (gal)	4.90	Water Volume (gal)	4.00	Water Volume (gal)	6.00
Minerals	Addition (gram/gal)	Calcium (ppm)	Magnesium (ppm)	Sodium (ppm)	Sulfate (ppm)	Chloride (ppm)	Bicarbonate (ppm)	Total Mineral Additions (grams)		Total Mineral Additions (grams)		
Gypsum ($CaSO_4 \times 2H_2O$)	0.10	6.2			14.7			0.49		0.4		
Calcium Chloride ($CaCl_2$)	0.20	19.1				33.8		0.98		0.8	Anhydrous	What form of
Epsom Salt ($MgSO_4 \times 7H_2O$)	0.00		0.0		0.0			0.00		0.0	10.0	Liquid $CaCl_2$ s
Magnesium Chloride ($MgCl_2 \times 6H_2O$)	0.00		0.0			0.0		0.00		0.0		Liquid $CaCl_2$ Soluti
Canning Salt (NaCl)	0.00			0.0		0.0		0.00		0.0		
Baking Soda ($NaHCO_3$)	0.00			0.0			0.0	0.00		Not Recommended	No	Add Sparging additions to t
Chalk ($CaCO_3$)	0.00	0.0					0.0	0.00		Not Recommended	No	Add Hardnes
Pickling Lime ($Ca(OH)_2$)	0.00	0.0					0.0	0.00		Not Recommended	No	Add $CaSO_4$ & & Lime in Spa
Acids	Addition				Sulfate (ppm)	Chloride (ppm)	Bicarbonate (ppm)					
Mash	(mL/gal)	Mash Acid Strength parameters are entered **below**						Total Acid Addition (ml)				Acid Anion Concentrat
Lactic	0.00	Strength	88.0	%	0.0	0.0	0.0	0.0				
	(mL/gal)							Total Acid Addition (ml)				
Phosphoric	0.00	Strength	10.0	%	0.0	0.0	0.0	0.0				
Sparge		**Sparge** Acid Strength parameters are entered on the **Sparge Acidication** sheet								Total Acid Addition (ml)		
Lactic		Strength	88.0	%	0.0	0.0				2.1	143	(ppm) Lacta
										Total Acid Addition (ml)		
		Strength			0.0	0.0				0.0		

Example 1. American Porter

Water Adjustment Summary

Hover cursor over cells w/ red corner marks to display helpful information

Black Full	Calcium (ppm)	Magnesium (ppm)	Sodium (ppm)	Sulfate (ppm)	Chloride (ppm)	Bicarbonate (ppm)
Existing Water Profile	36	9	14	26	25	107
Mashing Water Profile	61	9	14	41	59	107
Finished Water Profile	61	9	14	41	59	NA
Recommended Ranges	20 to 150	0 to 30	0 to 150	0 to 350	0 to 100	as needed

Mash Parameters					
Batch Volume (gallons)	6.00	Hardness (ppm as $CaCO_3$)	190	RA (ppm as $CaCO_3$)	38
Estimated Mash pH	5.17	Alkalinity (ppm as $CaCO_3$)	87	SO_4/Cl Ratio	0.7

Additions		Total Mash Water Vol (gal)	4.90	Total Sparge Water Vol (gal)	4.00
		Mash Dilution Vol (gal)	0.00	Sparge Dilution Vol (gal)	0.00
		Mash Water Additions		Sparge Water Additions	
Minerals		(grams)		(grams)	
Gypsum ($CaSO_4 \times 2H_2O$)		0.5		0.4	
Calcium Chloride ($CaCl_2$)	Anhydrous	1.0		0.8	
Epsom Salt ($MgSO_4 \times 7H_2O$)		0.0		0.0	
Magnesium Chloride ($MgCl_2$)		0.0		0.0	
Canning Salt (NaCl)		0.0		0.0	
Baking Soda ($NaHCO_3$)		0.0		Not Recommended	
Chalk ($CaCO_3$)		0.0		Not Recommended	
Pickling Lime ($Ca(OH)_2$)		0.0		Not Recommended	
Acids					
		0.0	(ml)		
		0.0	(ml)		
Lactic	88.00 %			2.1	(ml)
				0.0	(ml)

64 (ppm) Lactate added to water Expected to be under taste threshold

Example 2. Munich Helles

- Recipe:
  - 8.5 lbs Pilsner (2L), 1 lbs Vienna (3.5L)
  - 1.50 qt/lbs, 3.69 gal strike, 5.31 gal sparge
- Water Goal:
  - Low seasoning, sulfate forward
  - SO_4:Cl = 1.5

Example 2. Munich Helles

- Additions:
  - $CaSO_4$ 0.7 g (strike) + 1.1 g (sparge), CaCl 0.4 g (strike) + 0.5 g (sparge)
  - lactic 3.7 mL (strike)+ 2.2 mL (sparge)
- Result:
  - Ca = 54 ppm, SO4 = 57 ppm, Cl = 39 ppm
  - mash pH = 5.32 pH

Example 3. NE IPA

- Recipe:
  - 10 lbs 2 Row (2L), 2 lbs Flaked Oats (1L), 2 lbs Wheat Malt (2L)
  - No Sparge, 10.35 gal strike
- Water Goal:
  - Chloride forward, high seasoning
  - SO_4:Cl = 0.5

Example 3. NE IPA

- Additions:
  - $CaSO_4$ 3.6 g (strike), CaCl 7.8 g (strike)
  - lactic 5.2 mL (strike)
- Result:
  - Ca = 129 ppm, SO4 = 78 ppm, Cl = 152 ppm
  - Estimated mash pH = 5.20 pH
  - Measured mash pH = 5.44 pH
- Added 2 mL lactic to get 5.26 pH

Questions?

- Further Reading
  - GTA Brews Toronto Water Report Page
  - Bru'n Water – Water Knowledge
  - Water Book – By John Palmer and Colin Kaminski
  - Braukaiser - Mash pH Control
  - Scrappy Hound Brewing – Brewing Water
  - Toronto Water Reports
  - Milk the Funk pH Meter Page
  - Removing Chloramines From Water – A.J. deLange