Introduction to Brewing Water Part - I

Ryan Dunlop - True Grist - August 2018

This talk

- This talk will only contain a basic summary of how to deal with water.
- Chris K and Ryan D are creating a blog series to explain these concepts in greater detail for the nerds.
- This talk will go up on the website, so don’t fret the details.
- Yes, there will be science 🤓, but I will cliff note the rules 😎.
- I won’t go through it, but I’ve appended an example of Bru’n water to the end of the talk for the website.
- Please stop me at any time and ask questions as I go!

How Much Does Water Matter?

- Main ingredient. Beer is > 95% water
- Literally where all of the brewing chemistry takes place
- Influences flavour perception, colour, foam, clarity etc.
- Water can rarely make a bad beer good*, but can make a good beer great.
- Personal Take: Focus on other aspects first (yeast health and fermentation).

*** There are exceptions (Too much of certain minerals or chlorine!)**

Before I get going…

Let’s correct a misnomer

- “My water is really hard so I need to add a lot of acid” 🤔
- **Hardness** refers to Calcium and Magnesium concentrations…Most of which is calcium.
- **Alkalinity** refers to the resistance to lowering of the pH of the water to acid.
- Hard water is good! High alkalinity water is bad.
- Calcium and carbonate usually come in water together due to lime deposits (lime stone = $CaCO_3$), perhaps this is where that came from?

Outline

- Understand your local water
- Removal of chlorine compounds
  - If nothing else, do this!
- pH adjustment
  - What is it and how do you do it?
- Putting it together

Understand Your Local Water

- The website contains information about many <u>water profiles in our area.</u>
- Don't use softened water…Replaces Ca for 2xNa. 👎
- The most important things to know are:
  - Chlorine or Chloramine?
  - Concentrations of:
    - Ca, HCO_3, SO_4, Cl
  - pH

GUELPH (2017)

Ca^{+2}	Mg^{+2}	Na^{+1}	SO_4^{-2}	Cl^{-1}	HCO_3^{-1}	pH
118.5	37.8	64.6	106	150	352.3	7.9

KITCHENER-WATERLOO (MANNHEIM WATER TREATMENT PLANT, 2018)

Ca^{+2}	Mg^{+2}	Na^{+1}	SO_4^{-2}	Cl^{-1}	HCO_3^{-1}	pH
88	25	32	50	83	300	7.92

Chlorine and Chloramine

If you only get one thing from this talk…

- Used to disinfect water by the city.
- Not the same as chloride (Cl^-)!
- If not removed from water, reacts with malt and yeast to form “chlorophenols” which can taste medicinal/solvent.
- ***Awful*** flavour in beers.
- Typically one of chlorine or chloramine is used.
  - ie Guelph uses Chlorine, Kitchener uses chloramine
- Will use the term “chlorine” to denote both.

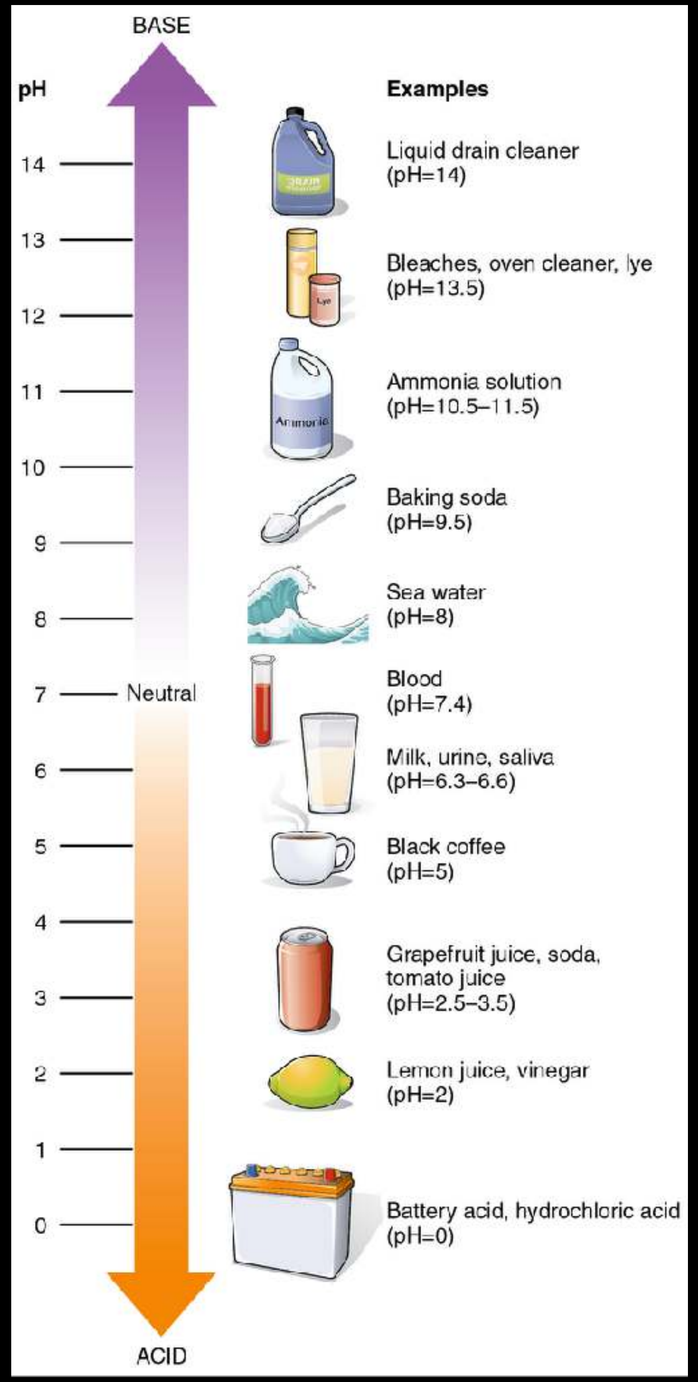
Removing Chlorine

	Time and/or preBoiling	Activated carbon Filtering	Campden/ MetaBisulfites/vitamin C
Chlorine	Leave water overnight, or get it up to boiling and chlorine will degas	1 gal/min	1/4 tablet per 5 gal Works almost immediately
Chloramine	✘	0.1 gal/min	1/4 tablet per 5 gal Works almost immediately

If you care: Campden and vitamin C actually reduces the molecules and turns them into chloride ions

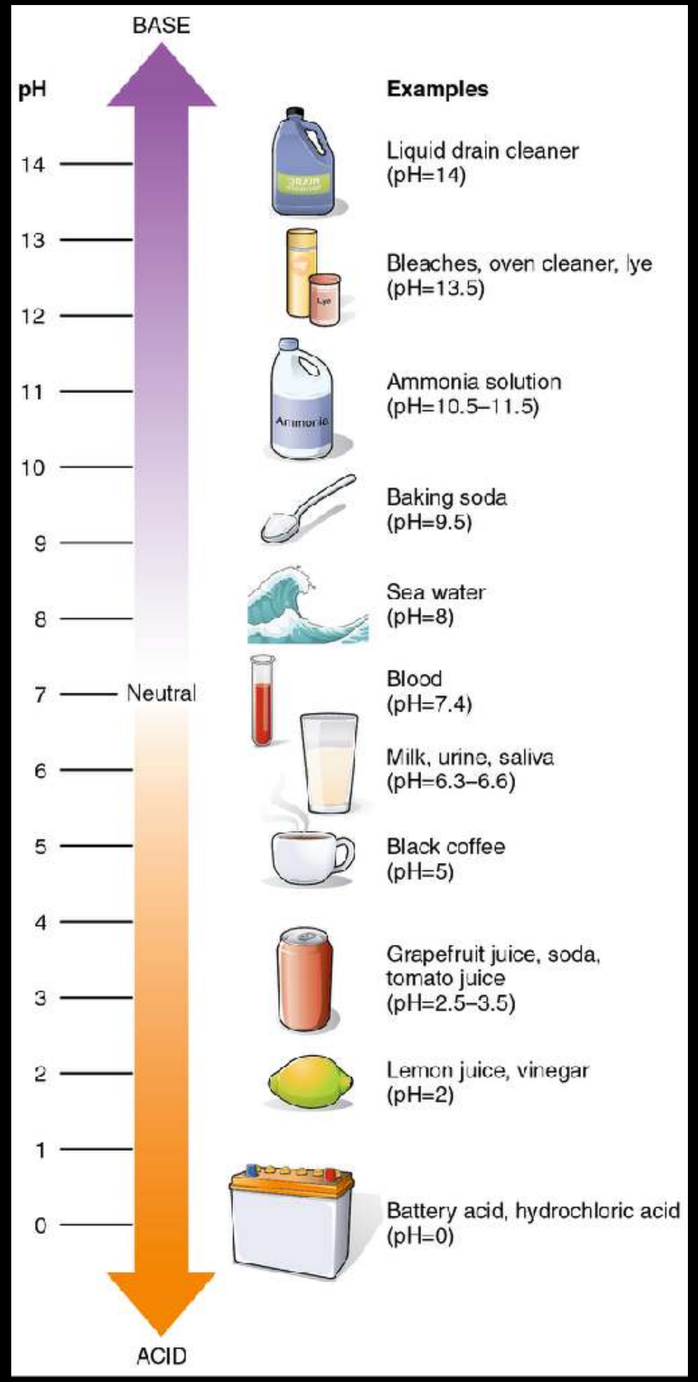
pH

- Along with some other great scientific achievements, this was invented at Carlsberg brewery… For beer!
- Concentration of “free” H^+ (actually H_3O^+) ions in water (logarithmic)
- Low = acid, high = alkaline, 7 = neutral pure water.
- pH of 6 is 10x more acidic than pH of 7, pH of 5 is 10x more.
- Acids are chemicals that give a solution more H^+



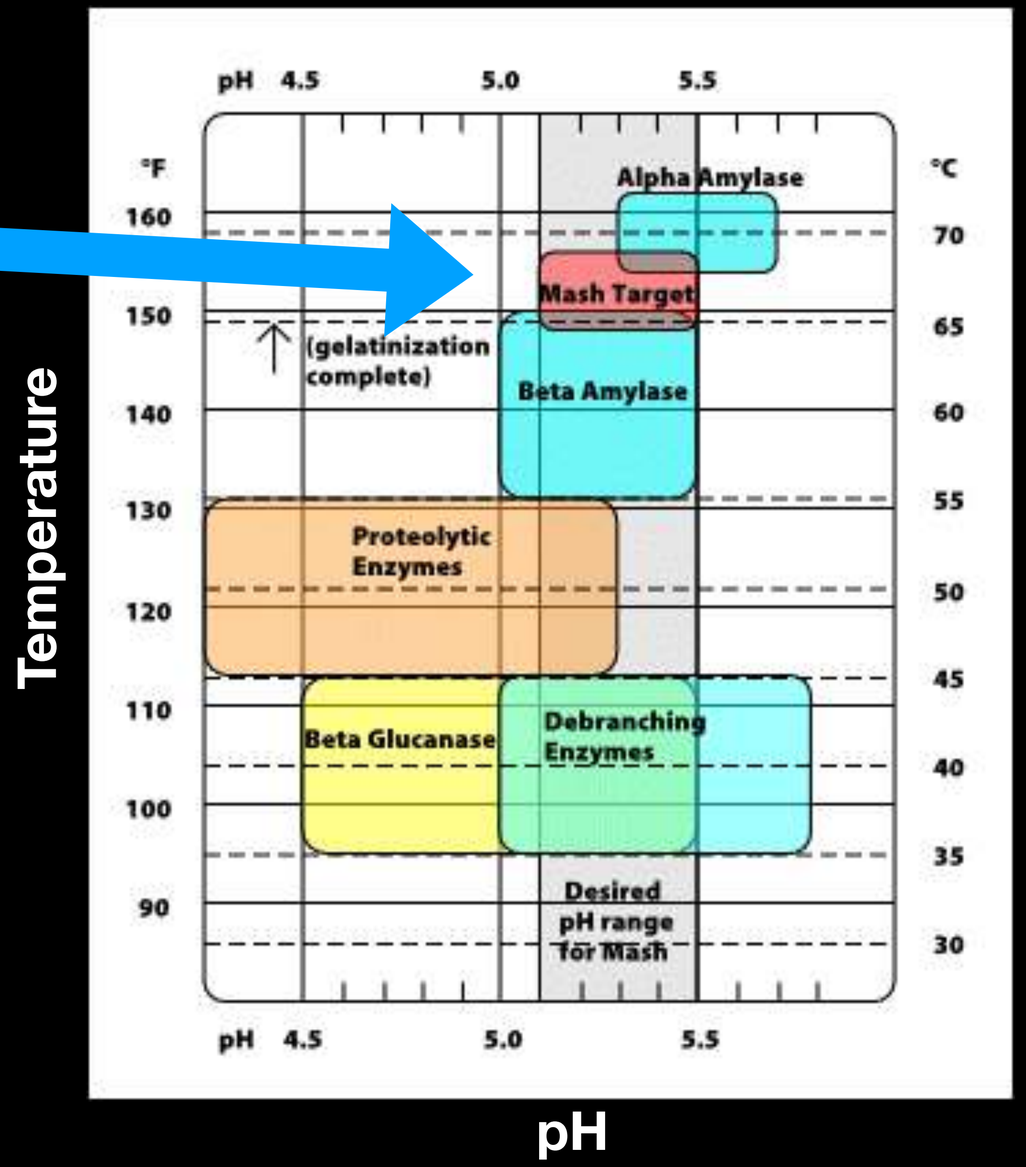
pH

- Tap water tends to be slightly alkaline pH~7.8 (for the sake of plumbing)
- pH can be lowered by the addition of acid, which add H^+.
- Mash pH can also be altered by the addition of salts and grains (see later).
- ions in the water (such as bicarbonate, HCO_3) can buffer, or cause solution to resist change to pH.



pH in Brewing

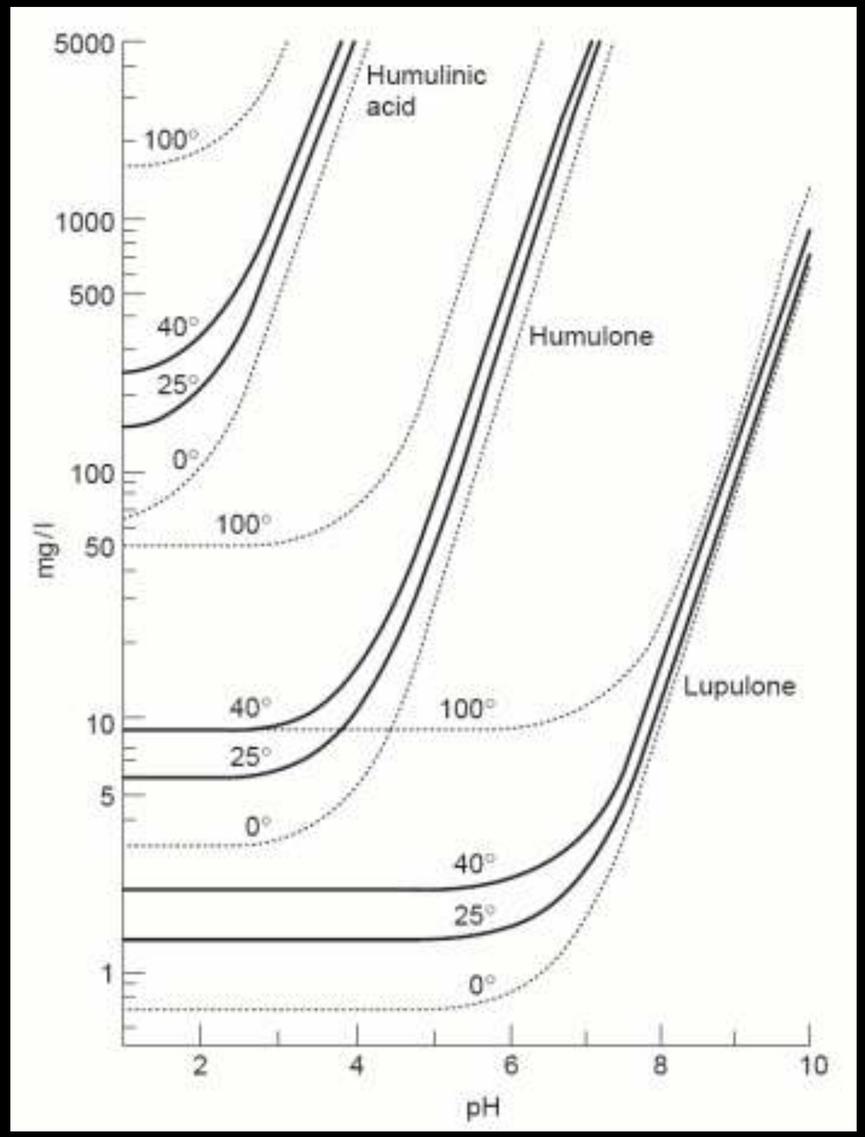
- Mash pH should be between 5.2 and 5.7 at room temperature (pH reads ~0.3 units lower at mash temp)
- Sparging pH should be kept below 6 to reduce tannin extraction.
- The boil drops the pH ideally to 5.0-5.2
- Final beer pH is generally in the low pH 4 range.
- Accomplish the first two, and the rest happens on it's own.



Getting the correct pH leads to…

Good Bitterness

- Crisp bitterness (not soapy or lingering)
  - alpha acids are more soluble at high-pH.
  - Not all are the same, some are worse than others!



http://braukaiser.com/

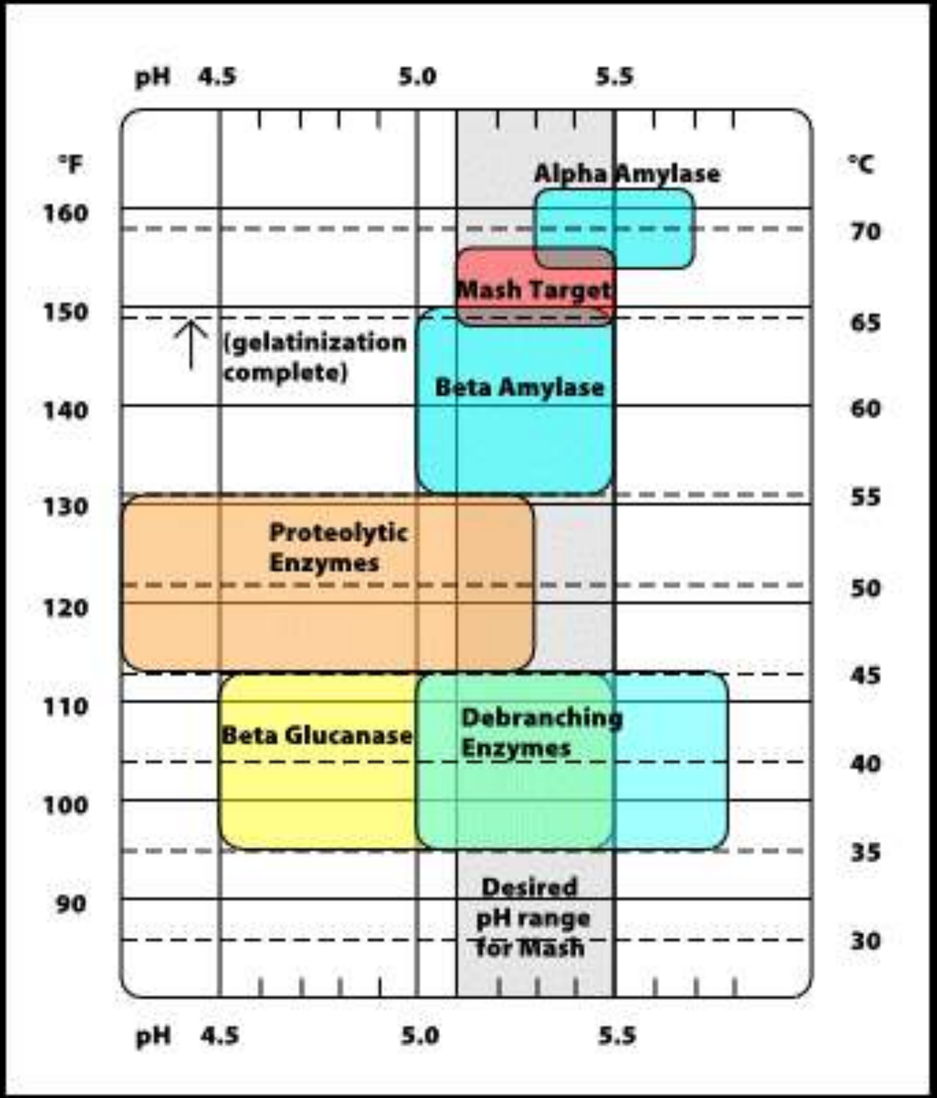
Less Colour Formation

- Left: Boiled for 15 minutes at pH of 5.5
- Right: Boiled for 15 minutes at pH of 6.5
- Maillard reactions occur more quickly at higher pH

http://braukaiser.com/

Conversion Efficiency

- Increased enzyme activity in the mash (better conversion)
- Aim for mash pH of 5.2-5.7 at room temp
- 5.5 is optimal for conversion, while many large breweries like Sierra Nevada aim lower than that (5.2) for flavour



Clarity

- Proteins in beer change shape and clump together most efficiently at pH = 4.9.
- The closer your pH is to this value, the more proteins are removed into trub.
- Also lack of husk tannins increase clarity and remove astringency.

Flavour

- Brighter, less “flabby”/dull tasting
- Better Bitterness
- Less astringency.
- Yeast reach terminal faster, clean up off-flavours more quickly

Acids and Buffers

How they work and why alkalinity matters

Adding phosphoric *acid* to water:

$$H_3PO_4 \rightarrow H^+ + H_2PO_4^-$$
$$H_2PO_4^- \rightarrow H^+ + HPO_4^{2-}$$
$$HPO_4^{2-} \rightarrow H^+ + PO_4^{3-}$$

pH decreases as H^+ increases!
These species form an equilibrium depending on pH

Acids and Buffers

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Why bicarbonate in brewing water SUCKS

$$CO_3^{2-} + H^+ \rightarrow HCO_3^-$$
$$HCO_3^- + H^+ \rightarrow H_2CO_3$$

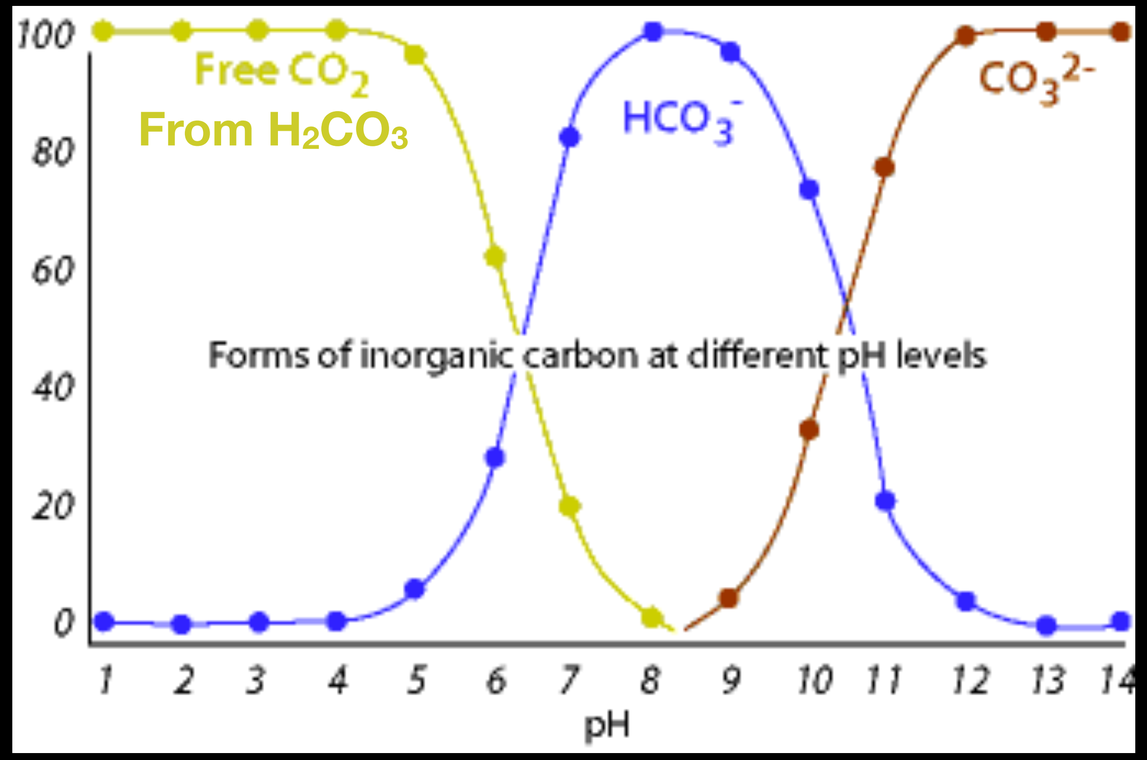
A lot of the acid you add gets "eaten" and doesn't change pH!
This is what we mean by a "buffer"

This is why alkalinity is bad

Acids and Buffers

How they work and why alkalinity matters

Nerd Graph



Adding Acid

Why bicarbonate in brewing water SUCKS

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A lot of the acid you add gets "eaten" and doesn't change pH! This is what we mean by a "buffer"

This is why alkalinity is bad

What can you do about it?

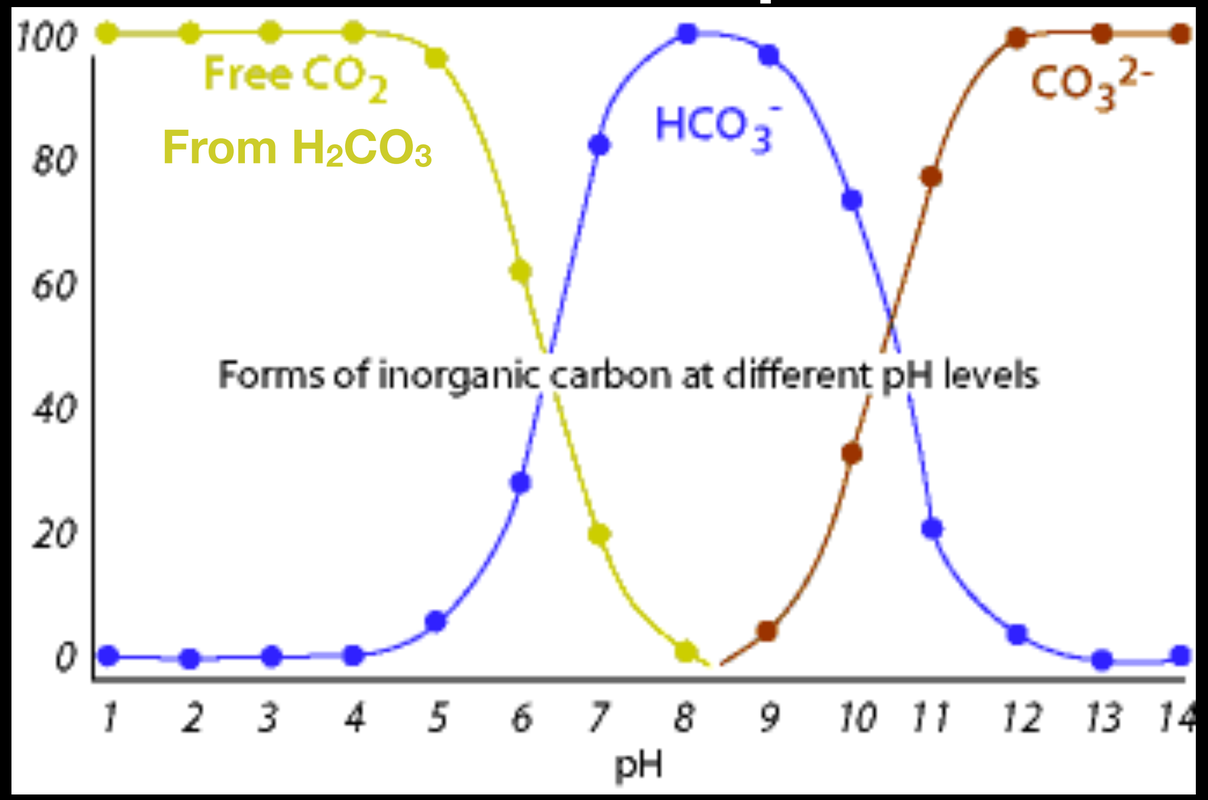
How to adjust pH

- Direct addition of acid (lactic or phosphoric), 88% lactic is ***<u>much</u>*** cheaper than acid malt.

- Can remove bicarbonate by boiling and precipitation of $CaCO_3$ …(I've got no time or energy for that/ Reduces Hardness)

$$CO_3^{2-} + H^+ \rightarrow HCO_3^-$$
$$HCO_3^- + H^+ \rightarrow H_2CO_3$$

Nerd Graph



Adding Acid

How to adjust pH

- Hard water is good!
- Additions of calcium based salts
  - Calcium reacts with phosphates in the malt to create acid! However, we have more than enough calcium in our water so salts shouldn’t be used as a complete substitute for acid!
  - Darker malts have more of these acid forming compounds…darker beers drop the mash pH more.

What is going on?

Example:

$$3Ca^{2+} + 2HPO_4^{2-} \rightarrow Ca_3(PO_4)_2 + 2H^+$$

Our previous hardness

Phosphates from the malt

Precipitates out (bone)

Acid!!!

- Darker malts have more of these acid forming phosphates!
- Don’t need to add as much acid
- Residual Alkalinity: The alkalinity after all Ca has been exhausted

Malt ⟹ Acid

Malt Type	Acid Production in mEq/lb of malt
Base Not stewed (<20 L)	0.28 x Colour in L
Crystal (Stewed) 1 L -> 200 L	0.21 x Colour in L + 2.5
Roast > 200 L	19
Acidulated	95

Courtesy of Bru'n water
(mEq = ppm as $CaCO_3$)

How not to adjust pH

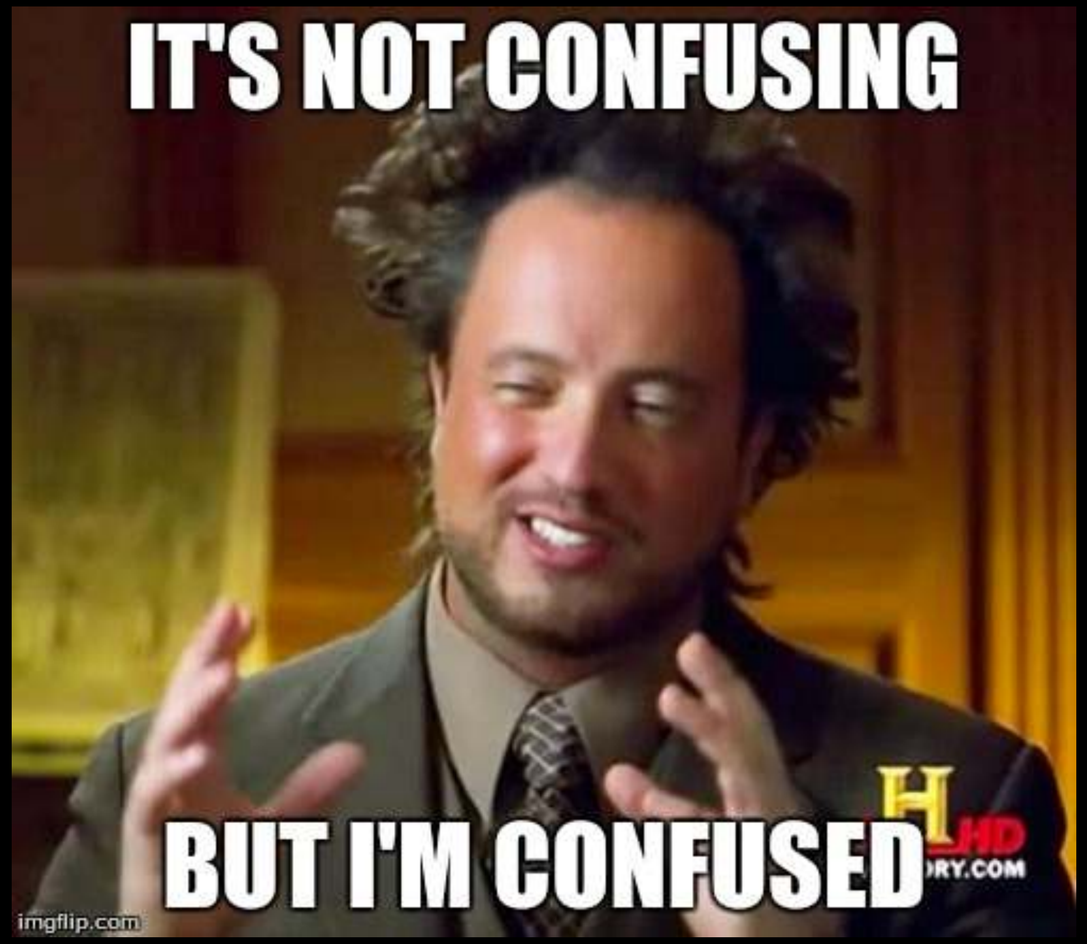
(My opinions)

- Don’t use 5.2 pH stabilizer. Our water is already highly buffered and the pH adjustment this product does is a drop in the bucket. All you are doing is adding Sodium salts!
- Just don’t add anything with Na at the front (baking soda etc)
- Stay away from acids that aren’t lactic or phosphoric. Lactic and phosphoric acids have high taste thresholds (among other reasons).
- Don’t add $CaCO_3$. This can be used to ***increase*** pH. We don’t need that here. It also doesn’t dissolve well. If you want to increase pH use pickling lime [$Ca(OH)_2$]

Measuring pH

- pH meter: 0.1 accuracy and resolution should be good enough, but 0.01 is nice.
- Buffers: pH 4 <u>and</u> 7 buffers work well for calibrating for beer.
- Test strips can be used, but are <u>very difficult</u> to read, known to be wrong by about 0.3 units
- Cool down sample of mash after about 10-15 minutes of mashing once malt reactions have taken place. (pH is temperature dependent!) Your pH probe will thank you.
- If I measure pH. I adjust pH before mashing. I will only add acid after this point if the pH is WAY off. Otherwise, this measurement is mostly to inform the next brew day.

Putting it all together



Dealing with Chlorine
How I brew

- The first thing I do, is learn about my water. It's Guelph water = chlorine. I pour some softner-***bypassed*** water into a bucket the day before brewing

- Depending on the style, I also like to cut my tap water with RO water just to reduce all minerals and carbonate, and use less acid. This is just my preference.

Treating Water

- I use a cheap medicine syringe to measure out my lactic acid and add it to my water.
- I start mashing, wait 5-10 minutes, take a small sample, cool it, ***calibrate my pH meter*** and take a pH reading….
- Maybe add ~0.2 mL acid/gal mash water per 0.1 pH point if I want to drop pH further (based on my water).
- I only check pH every once in a while now (laziness + Bru'n water is usually correct!)

How much acid I use

I generally mash between 1.25 qt/lb to 1.5 qt/lb all of these are 1.5 qt/lb
I add 88% Lactic acid, 6 gallon batch, pH ~5.3 at room temp

	50:50 RO:Tap Acid	Pure Tap Acid	Weight and volumes
Pilsner 3 SRM 1.050 OG	5.5 mL mash 3 mL Sparge	8 mL mash 6 mL sparge	10.5 lb malt 15.75 qt mash 4.36 gal sparge
Vienna Lager 10 SRM 1.050	4 mL mash 3 mL sparge	6 mL mash 6 mL sparge	10.7 lb malt 15.75 qt mash 4.38 gal sparge
Porter 28 SRM 1.051 OG	Too acidic!!!	0 mL mash 6 mL sparge	10.75 lb malt 15.75 mash 4.38 gal sparge

How much acid in “no sparge”

	Batch Sparge	No Sparge
Pilsner 3 SRM 1.050 OG 50:50 RO:Tap	5.5 mL mash 3 mL Sparge	12.5 mL mash
Pilsner 3 SRM 1.050 OG Pure Tap	8 mL mash 6 mL sparge	17 mL mash

General trends

If you don't want to use a calculator

Sparge Water, aiming for pH = 6:

- Pure Guelph~Kitchener water takes about 1.3 mL lactic per gallon
- 50:50 RO:Tap taks about 0.7 mL lactic per gallon

Mash Water (for pure tap):

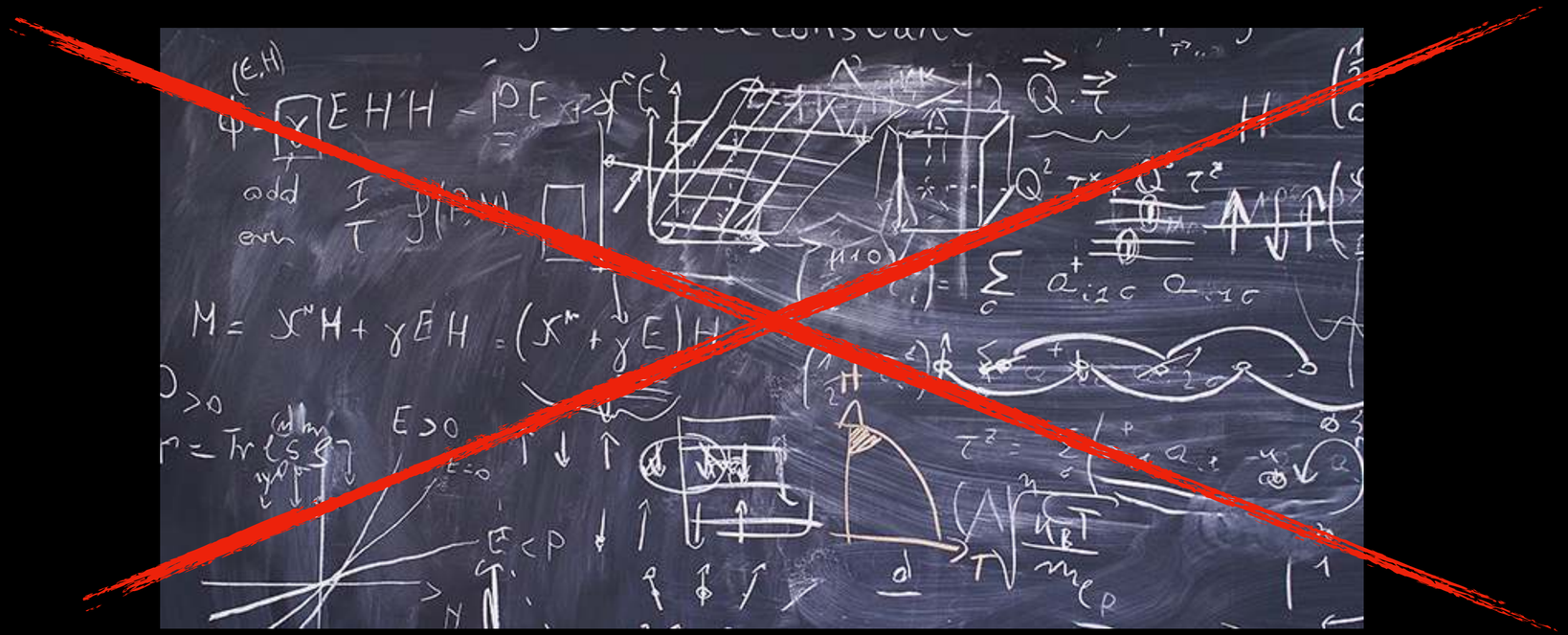
- 6-8 mL for **pale beers**, 3-6 mL for **amber beers**, 0-3 mL for **darker beers**
- Depends on dilution
- "No spargers" (BIAB) will have to use slightly more acid overall.
- Consideration: 8.5 mL total in 5 gallon batch is quoted "Taste Threshold" of 400 ppm. Previous slides were 6 gal.

Summary

- Water is ***not*** the most important thing!
- Understand your water; need to know where you are before you can get to your destination
- Water chemistry can be complicated. Treating water is easy. You don't need a chemistry degree, just some simple rules.
- 1st: Remove Chlorine!
- 2nd: Get a good pH!
- Future talk on salt additions…

Summary

- Dealing with water is not as difficult as it sounds



- Simple, cheap changes to water can result in better tasting beer

Questions or Comments?

Thanks for your attention!

If you want to dive in deeper:
http://braukaiser.com/
https://sites.google.com/site/brunwater/water-knowledge

Water Report

- I obtain my water profile from truegrist.ca …

GUELPH (2017)

Ca^{+2}	Mg^{+2}	Na^{+1}	SO_4^{-2}	Cl^{-1}	HCO_3^{-1}	pH
118.5	37.8	64.6	106	150	352.3	7.9

…and input it into bru'n water on *Water Report Input* page.

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)	118.5	352.8	Bicarbonate (HCO_3)
Magnesium (Mg)	37.8	1.0	Carbonate (CO_3)
Sodium (Na)	64.6	105.4	Sulfate (SO_4)
		128.3	Chloride (Cl)

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)
290.9	7.9	352.3	1.3

Water Report

- I obtain my water profile from truegrist.ca …

GUELPH (2017)

Ca^{+2}	Mg^{+2}	Na^{+1}	SO_4^{-2}	Cl^{-1}	HCO_3^{-1}	pH
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Calculated by cells above

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290.9	7.9	352.3	1.3

Recipe: Doppelbock

Total Water Additions				Total Batch Volume	
Mash		Sparge			
Water Volume (gal)	5.86	Water Volume (gal)	3.86	Water Volume (gal)	6.00

- Go to “Water Adjustment” page
- Add the mash and sparge volume (I’m going to use 1.25 qt/lb):

- I use 50% RO water, so I add that on this page as well.

RO Water		1	0	8	1	4	16
Percent Dilution Water	50	64	oz/gal	4	pt/gal	< These conversions are p	

Recipe: Doppelbock

Sparging Water Acidification Calculator

INPUTS			
Starting Water Alkalinity =	291	ppm as $CaCO_3$	
Starting Water pH =	7.9	Standard Units	
Type of Dilution Water Used	RO Water	< Select	
Percent Dilution Water	50	percent	
Diluted Water Alkalinity	152	ppm as $CaCO_3$	
Diluted Water pH	7.2	Standard Units	
Set the Target Water pH =	6.0	Standard Units	
Water Volume to Treat=	1.0	Gallons	Input 1.0 for the vol
First Acid Type =	Lactic	Acid type used in sparging water	
First Acid Strength =	88	%	< Select
Second Acid Percentage	0	percent	
Second Acid Type =	Phosphoric	Acid type used in sparging water	
Second Acid Strength =	10	%	< Select

- On “Sparge acidification” sheet, insert pH, water type,dilution and target pH. I used 6.0. The rest will be calculated automatically on the water treatment sheet.

Recipe: Doppelbock

- Go to “Grain Bill Input”
- Add the grains, types, amounts, colours.

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
Munich I	Base Malt	14.0	0.0	7.1	74.7
Pilsner	Base Malt	2.0	12.0	1.7	14.7
Caramunich I	Crystal Malt	2.0	0.0	51	10.7

Recipe: Doppelbock

- Go to “Water Adjustment” page

Estimated Mash pH	5.66

Acids	Addition				Sulfate (ppm)	Chloride (ppm)	Bicarbonate (ppm)		
Mash	**(mL/gal)**	**Mash** Acid Strength parameters are entered **below**						Total Acid Addition (ml)	
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			**5.2**
									Total Acid Addition (ml)
		Strength			0.0	0.0			**0.0**

- Calculate Acids (guess and check for mash)

Sparge pH is automatically calculated on “Sparge Acidification” Page

Recipe: Doppelbock

- Go to “Water Adjustment” page

Estimated Mash pH	5.27

Acids	Addition				Sulfate (ppm)	Chloride (ppm)	Bicarbonate (ppm)		
Mash	(mL/gal)	**Mash** Acid Strength parameters are entered **below**						Total Acid Addition (ml)	
Lactic	**0.75**	Strength	88.0	%	0.0	0.0	-138.5	**4.4**	
	(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			**5.2**
									Total Acid Addition (ml)
		Strength			0.0	0.0			**0.0**

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