The Water Talk

VIBE August 2017

TL; DR

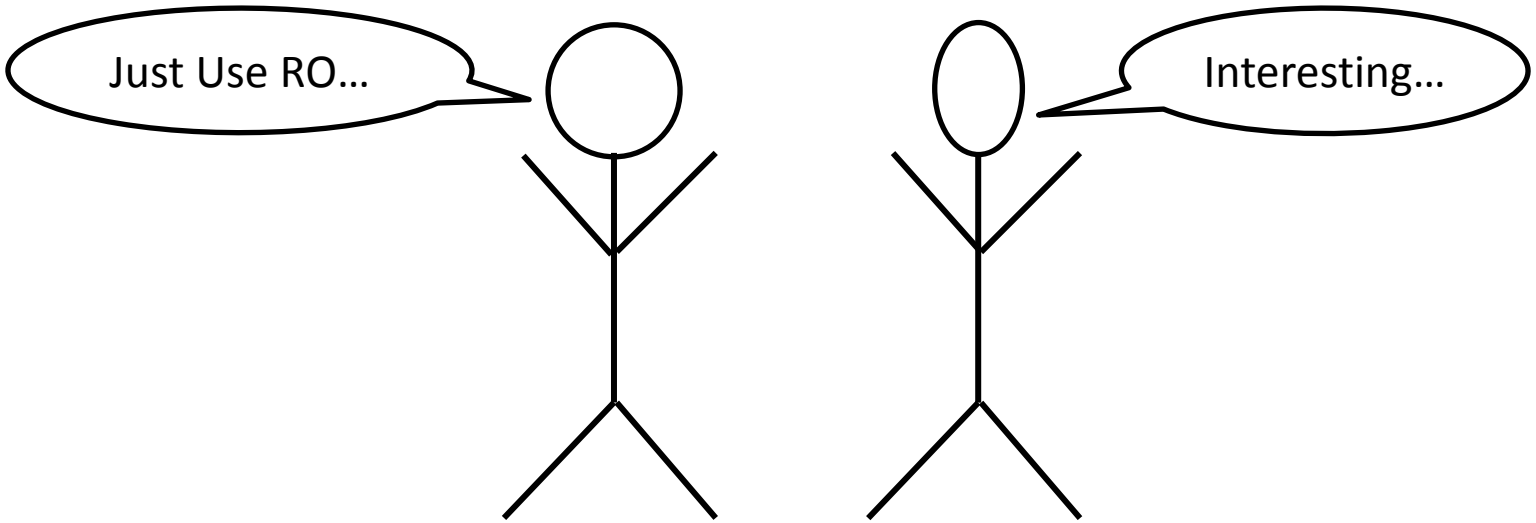
Water is **critical** at all stages of beer production

When in doubt: **use reverse osmosis** water for

- Brewing
- Making cleaners
- Making sanitizers

A Story

- Circa 2011, Andy has homebrew problems
- Andy goes to Surf Homebrew, meets Doug E.
- I mention some of my issues
- He says “Just use RO water for everything”



Overview

What is Water?

Science

Thru the Brew: How to control water

Water addition calculators

Statistical Significance

Water Chemistry

It's so weird for me to think that just a couple years ago, I claimed in a friendly argument with another brewer that water chemistry was of minor importance, contending that people likely wouldn't be able to taste a difference between a beer with a defined profile and one where the water was left alone. Could I have been more wrong?

When it comes to water chemistry, the 2 general components are mineral content and pH, both of which we've performed multiple xBmts that have yielded fascinating results. Most curious to me has been the evidence suggesting mash pH out of the typically accepted range doesn't seem to have nearly the impact on efficiency, aroma, or flavor as expected. On the other hand, multiple xBmts have demonstrated how differences in mineral content tend to produce perceptible differences in the finished beer.

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What is Beer?

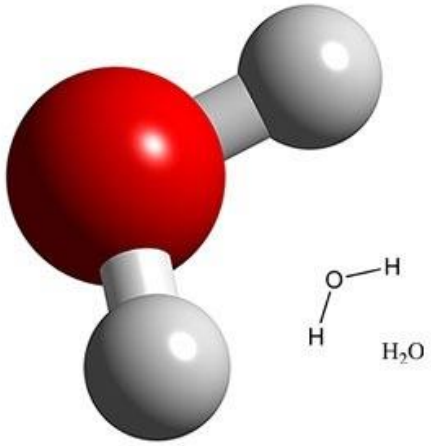
Malt

Hops

Yeast

Water

What is Water?



Dihydrogen Monoxide

“Pure water” pH = 7

Minerals, gases always dissolved in it

- From the ground, from air pressure

~95% of beer by volume

<u>We care very much what is dissolved in it!</u>

What is pH?

Measure of free hydrogen (H+) in a liquid

$H_2O \leftrightarrow H^+ + OH^-$ (equilibrium)

Log scale: $pH = - \log_{10} [H+]$

Moving 1 point on pH is 10x change in H^+

pH has major impact in chemical reactions

<u>Controlling wort/beer pH is crucial for repeatable brewing</u>

What is pH?

Best to measure at room temperature

- Probe calibration
- Comparison between brewers
- Room temp to mash temps = subtract 0.25 pH *

Milwaukee pH Meter w/ATC

$134.99 ★★★★★ 14 Reviews

Item #: MT609
Shipping: Eligible for Free Shipping Program
Weight: 2LBS
Availability:California - In Stock
Pennsylvania - In Stock

ph meter

High Accuracy pH Meter w/ Replaceable Electrode (8689)

☆☆☆☆☆ Write a Review | 8 Questions, 19 Answers
SKU: #8689

$69.00
On Sale, *normally $85*

Quantity 1

Add to Cart

* Braukaiser wiki

Thru The Brew

Cleaning

Sanitizing

Brewing

- Mash
- Boil
- Post-fermentation

Water at Home

Untreated Tap Water

Usually a non-starter → chlorine/chloramine

Carbon block filter → removes chlorine

May not be enough for chloramine

Tips: flow slowly, do not run hot water

Reverse Osmosis System → Ideal

Reduce minerals by at least 90%

Carbon pre-filter will strip chlorine/chloramine

Can be expensive to operate, reject water (water hog…)

Chlorine in Beer: plastic, phenolic, rubbery

Could also be an infection, needs cross-check

Chloramine

Ammonia with attached chlorine

Provides disinfectant with long shelf life

- But will break down over time to Cl_2
- $Cl_2 \rightarrow ClO^-$, ClO^- + organics = chlorophenols

Hard to remove with carbon block

- Need activated/granulated carbon

Simple trick: Campden tablets

- Bind to Cl_x compounds, free Cl^-
- Minor amounts of change to water chemistry

Cleaners

Basic (alkaline) chemicals

Usually contains “agents” to help deal w/ hard water

Feels “soapy” to the touch

Examples: PBW, Oxiclean, One-Step

Sanitizers

Acidic chemicals

Usually includes an active ingredient (iodine, sulfur)

Feels “drying” to the touch

Example: StarSan, Saniclean, Iodophor

Making Cleaners/Sanitizers

Obvious: tap water

- High mineral content water decreases shelf life
- Best to carbon block filter too

Reverse Osmosis

- Much longer chemical shelf life
- Grocery, water stores → ~ $0.30/ gallon

Sanitizers are NOT Cleaners

Cleaners are NOT Sanitizers

Sanitizers are NOT Cleaners

Cleaners are NOT Sanitizers

Water Minerals & Flavor

Calcium: Cause of “hard” water, helps regulate mash pH, yeast flocculation. Minor flavor impact

Magnesium: Also “hard” water, yeast nutrient

Bicarbonate: Alkaline (base) control of mash

Sodium: “Roundness” of flavor

Chloride: NOT Chlorine!, “fullness” or “sweetness”

Sulfate: “Sharp”, “Drier”, combine w/hops

Bru’n Water

Making Brewing Water

Tap Water: Random levels of minerals, unpredictable if from wells. Also chlorine or chloramine.

Carbon Block Water: Will remove chlorine, potentially chloramine, but not mineral content.

RO + Minerals: Chlorine and chloramine removed (carbon block in line), 10x reduction in mineral content compared to local levels. Must bring up mineral content in many cases.

How to Add Minerals

Calcium Sulfate (Gypsum)

Calcium Chloride

Magnesium Sulfate (Epsom Salt)

Magnesium Chloride

Sodium Chloride (Salt. Not “Table Salt”)

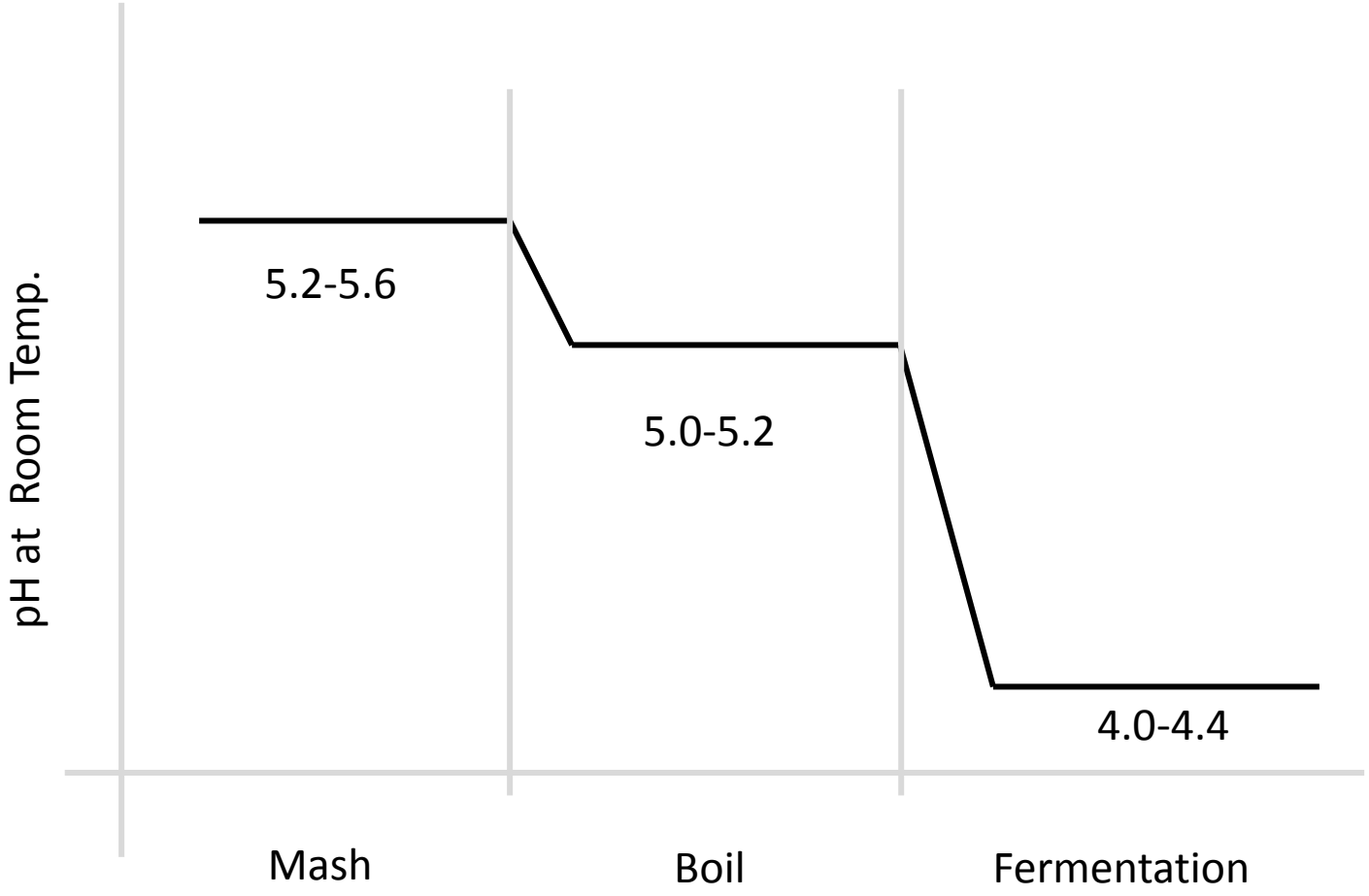
Sodium Carbonate (Baking Soda)

Calcium Carbonate (Chalk)

Calcium Hydroxide (Pickling Lime)

Acids: **Lactic**, Citric, **Phosphoric**

Brewing: pH over Brew



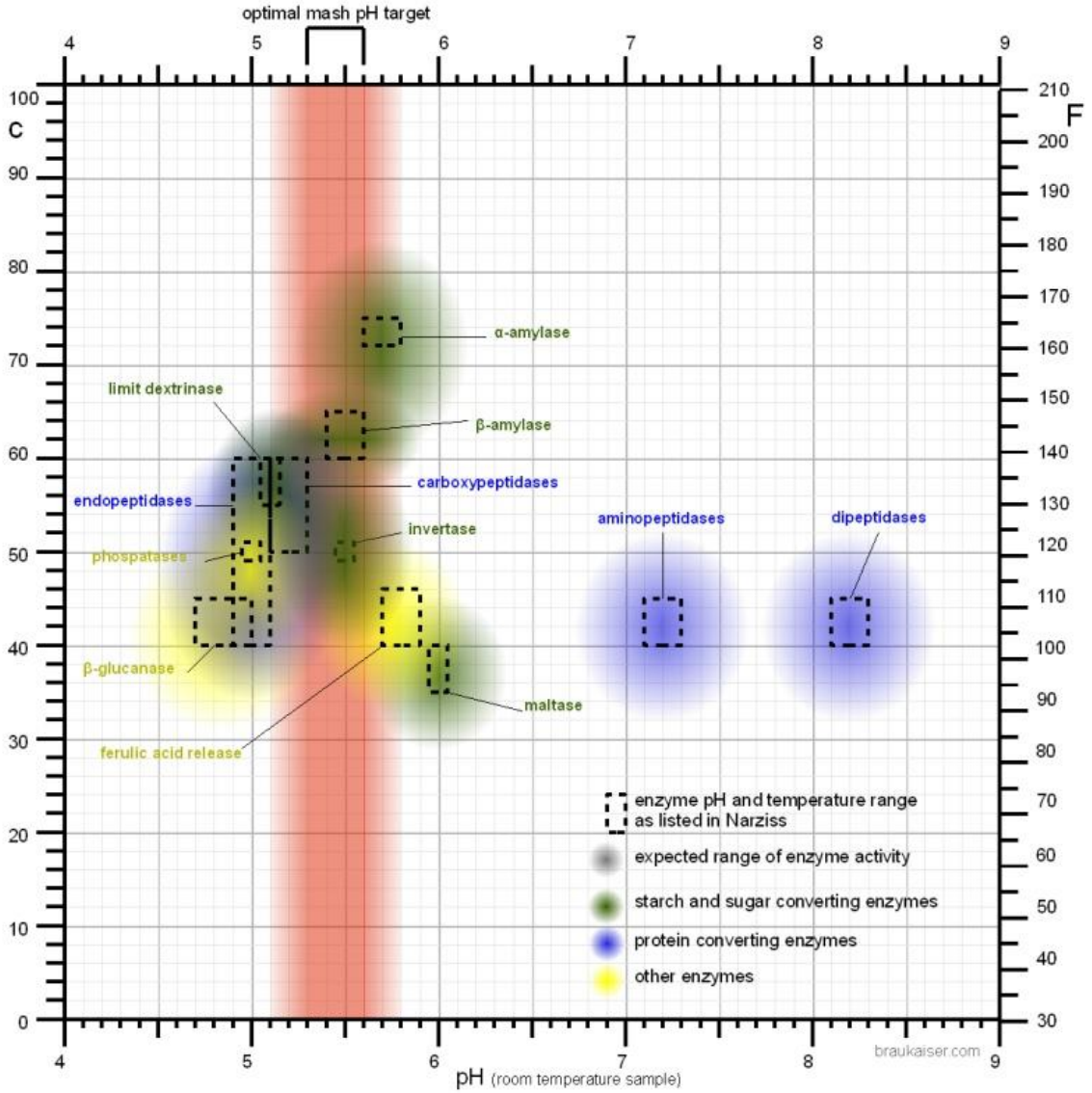
Brewing: Mashing

Mashing: process of converting malt starches into simple sugars digestible by Saccharomyces

Temperatures: 144-163F

pH (RT measurement): 5.2-5.6

Brewing: Mashing



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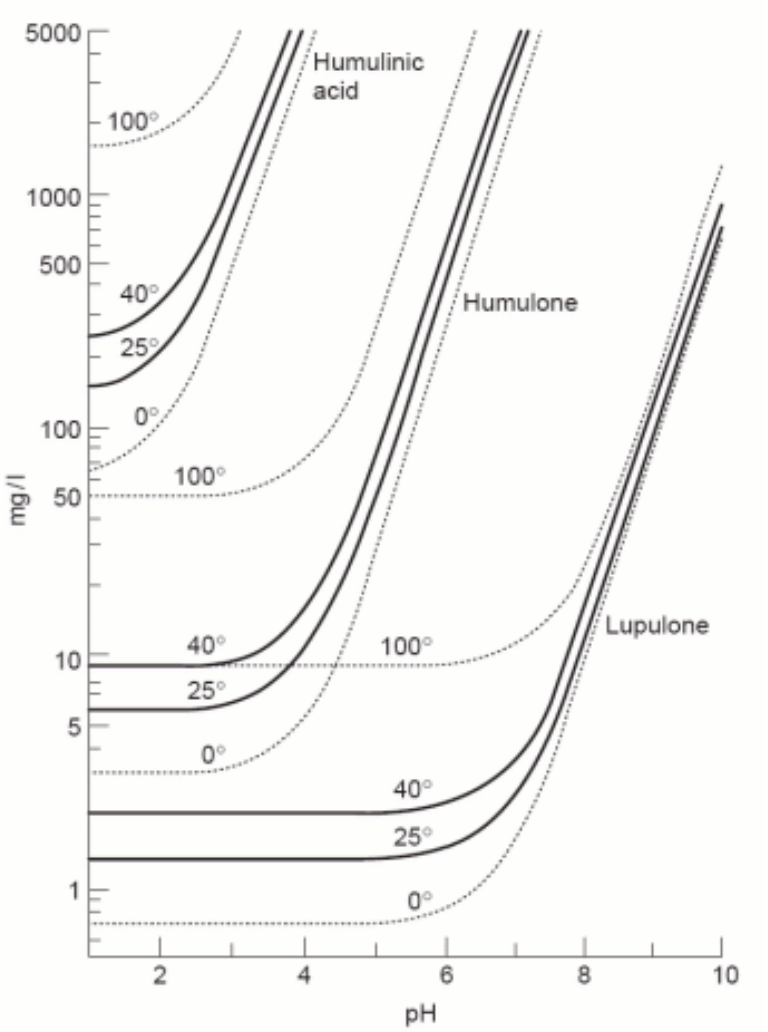
Brewing: Boiling

pH: Start of boil, 5.0-5.2.

Usually drops 0.1 during boil

Hops and pH: Bitterness extracted is affected by boil pH. Best practice is to standardized pH



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Brewing: Fermentation

pH: yeast will generate lactic acid → lower pH

Start: ~5, lowered to 4.0-4.4

→ ABV and pH cause microbial stability!

Issues with pH could note poor yeast health

<u>Diacetyl and pH</u>

α–acetolactate → diacetyl → acetoin → butanediol

(precursor) *oxidation* *yeast* *(hard to taste)*

Precursor to diacetyl: driven by optimized pH! (4.2-4.4)

Empirical : hoppy beers + American ale yeast → more diacetyl

→ yeast health? pH control? Hop interaction? Not clear

Brewing: Post-Fermentation

pH and Titratable Acidity

→ flavor control of final beer

Carbonation: Slightly lowers pH (carbonic acid)

Adjusting Water: Bru'n Water

Bru'n Water

Instructions

Created by Martin Brungard, P.E. D.WRE (mabrungard@hotmail.com)

Most water sources that have an acceptable taste can be used to brew beer. But to brew great beer across a wide variety of styles, adjustment of brewing water is probably needed. **Bru'n Water** is a brewing water analysis program that enables a brewer to successfully evaluate and modify their water supply to improve their beer. The program steps through the evaluation of a brewer's water supply, adjustment to a desired water profile, evaluation of potential mash pH, and adjustments to produce desirable mash pH.

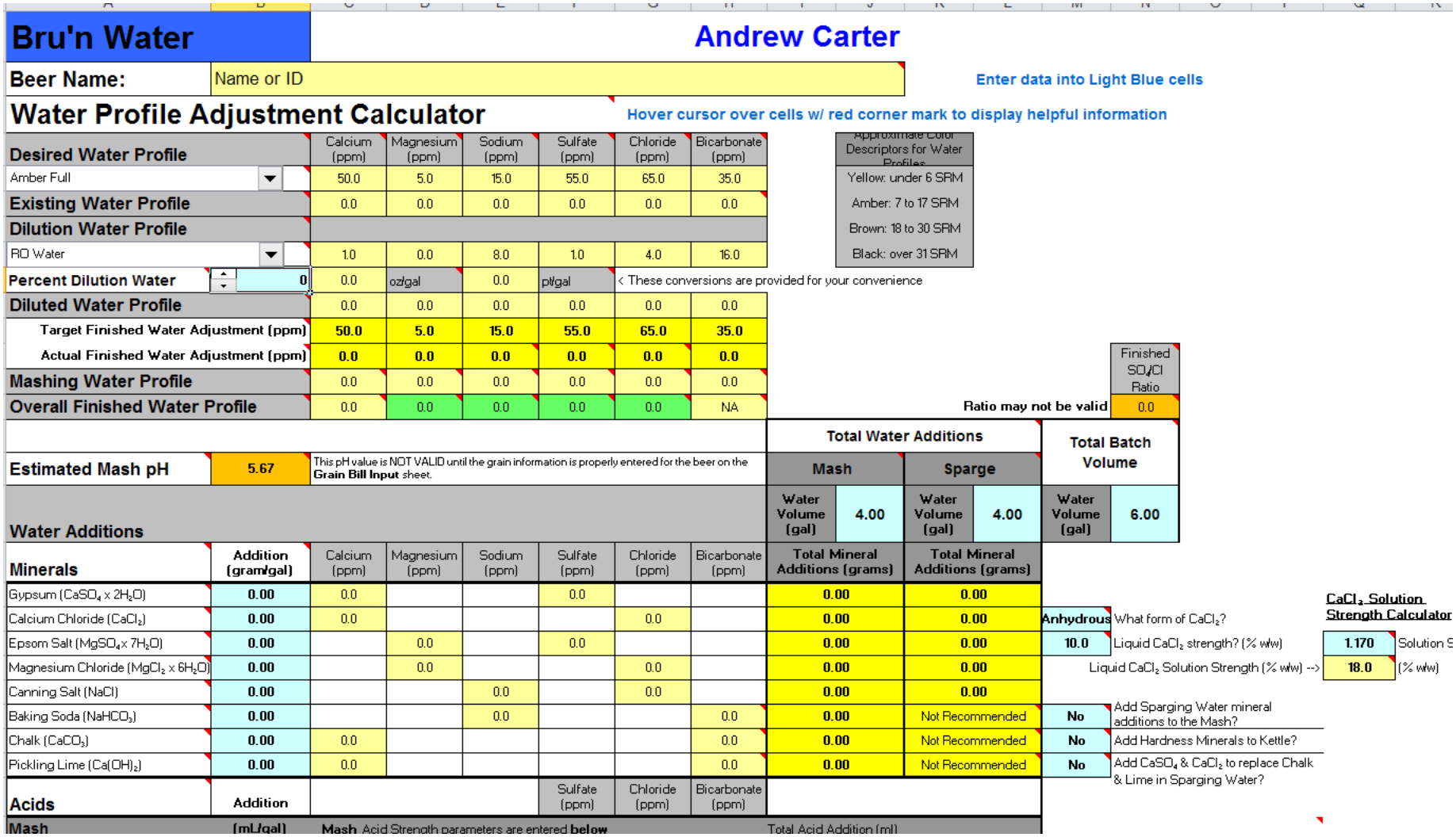
Homebrewing and Craftbrewing are unique in their need to frequently assess and adjust their brewing water to better suit their upcoming beer. This differs from the needs of production breweries that brew thousands of barrels of the same beer every year. Consistency is the key for production brewers and they have little need to evaluate or change their brewing water. Through trial and error and advanced laboratory analyses, production breweries typically know exactly what adjustments they need for their brewing water. Homebrewers and Craftbrewers rarely have the tools at their disposal to perfect their water and since they often change what beer they brew, a capable tool is helpful. This brewing tool is intended to aid those who want to get great results out of every batch.

Getting Started

The first thing needed for brewing water analysis is to know your water supply characteristics and ion concentrations

0. Instructions | 1. Water Report Input | 2. Sparge Acidification | 3. Grain Bill Input | 4. Water Adjustment | 5. Adjustment Summary | Raw Text Summary | Water Knowledge

Adjusting Water: Bru’n Water



Bru'n Water — **Andrew Carter**

Beer Name: Name or ID

Enter data into Light Blue cells

Water Profile Adjustment Calculator

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

	Calcium (ppm)	Magnesium (ppm)	Sodium (ppm)	Sulfate (ppm)	Chloride (ppm)	Bicarbonate (ppm)
Desired Water Profile						
Amber Full	50.0	5.0	15.0	55.0	65.0	35.0
Existing Water Profile	0.0	0.0	0.0	0.0	0.0	0.0
Dilution Water Profile						
RO Water	1.0	0.0	8.0	1.0	4.0	16.0
Percent Dilution Water 0	0.0	oz/gal	0.0	pt/gal	< These conversions are provided for your convenience	
Diluted Water Profile	0.0	0.0	0.0	0.0	0.0	0.0
Target Finished Water Adjustment (ppm)	**50.0**	**5.0**	**15.0**	**55.0**	**65.0**	**35.0**
Actual Finished Water Adjustment (ppm)	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Mashing Water Profile	0.0	0.0	0.0	0.0	0.0	0.0
Overall Finished Water Profile	0.0	0.0	0.0	0.0	0.0	NA

Approximate Color Descriptors for Water Profiles
- Yellow: under 6 SRM
- Amber: 7 to 17 SRM
- Brown: 18 to 30 SRM
- Black: over 31 SRM

Finished SO_4/Cl Ratio: 0.0 — Ratio may not be valid

Estimated Mash pH 5.67 — This pH value is NOT VALID until the grain information is properly entered for the beer on the **Grain Bill Input** sheet.

	Total Water Additions				Total Batch Volume	
	Mash		Sparge			
Water Additions	Water Volume (gal)	4.00	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 ($CaSO_4 \times 2H_2O$)	0.00	0.0			0.0			0.00	0.00
Calcium Chloride ($CaCl_2$)	0.00	0.0				0.0		0.00	0.00
Epsom Salt ($MgSO_4 \times 7H_2O$)	0.00		0.0		0.0			0.00	0.00
Magnesium Chloride ($MgCl_2 \times 6H_2O$)	0.00		0.0			0.0		0.00	0.00
Canning Salt (NaCl)	0.00			0.0		0.0		0.00	0.00
Baking Soda ($NaHCO_3$)	0.00			0.0			0.0	0.00	Not Recommended
Chalk ($CaCO_3$)	0.00	0.0					0.0	0.00	Not Recommended
Pickling Lime ($Ca(OH)_2$)	0.00	0.0					0.0	0.00	Not Recommended

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

Anhydrous	What form of $CaCl_2$?
10.0	Liquid $CaCl_2$ strength? (% w/w)
	Liquid $CaCl_2$ Solution Strength (% w/w) --> 18.0 (% w/w)
No	Add Sparging Water mineral additions to the Mash?
No	Add Hardness Minerals to Kettle?
No	Add $CaSO_4$ & $CaCl_2$ to replace Chalk & Lime in Sparging Water?

$CaCl_2$ Solution Strength Calculator

1.170 Solution S

Adjusting Water: Bru’n Water

HEYFIT

HEYFIT 500g/0.01g Digital Pocket Scale Jewelry Gram Food Scale Stainless Steel 0.001oz Resolution (500g/0.01g)

59 customer reviews | 12 answered questions

Price: $26.99

Sale: $11.99 prime

You Save: $15.00 (56%)

In Stock.

5 gal. batch -- > grams of minerals

Accurate scale critical for water adjustment

A Contrarian View

At 15 minutes into either mash rest, I pulled samples to measure the pH, which showed the adjustments I made did what they were supposed to do.

Left: standard pH

To say I was nerv

| RESULTS |

A panel of 20 people with varying degrees of experience participated in this xBmt. Each taster, blind to the variable being investigated, was served 2 samples of the normal pH beer and 1 sample of the high pH beer in different colored opaque cups then instructed to select the unique sample. With the given sample size, a total of 11 ($p<0.05$) correct selections would have been required to achieve statistical significance, though only 8 tasters ($p=0.34$) chose the different beer, indicating tasters were unable to reliably distinguish a beer produced with a higher than recommended mash pH from one produced with a normal mash pH.

brulosophy.com

Conclusions

Brewing is process control (science) and creativity (art)

Basic knowledge/practice will allow you to practice art

Consistent decision making will minimize brew risk

When in doubt, start with reverse osmosis water!

Further Reading

- Modern homebrew water books
- Bru’n Water:

https://sites.google.com/site/brunwater/

- Braukaiser Wiki:

http://braukaiser.com/wiki/index.php/

- Brulosophy:

http://brulosophy.com/