Intro to Brewing Water Treatment

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Why Treat Brewing Water?

- Hit desired Mash pH
- Tweak Flavor Profile
- Aid Yeast Flocculation

Why is Mash pH Important?

pH is the negative of the base 10 logarithm of the molar concentration, measured in units of moles per liter, of hydrogen ions. $pH = -\log [H^+]$. pH = 7.0 is "neutral."

- Better Mash Efficiency
  - pH 5.2 to 5.6 recommended
- Avoid Overly Dark Wort/Beer
  - Higher pH causes wort to darken in boil due to increased Maillard reactions
- Reduce risk of extracting Tannins
  - High pH (above ~6.0, especially w/ high temps) causes Tannins to be extracted from grain husks --> Astringency

What Affects Mash pH?

Alkalinity is the capacity of a solution to resist changes in pH by neutralizing acids.

- Alkalinity of the Base Water
  - Alkalinity is the capacity of a solution to resist changes in pH by neutralizing acids
- Acidity contributed by Grains
  - Darker grains contribute more acidity. (But it's *not* linear. Throw away your Palmer nomograph.)
- Calcium or Magnesium Ions
  - Ca^{+2} and Mg^{+2} react with phosphates in the malt, releasing H^{+} ions.
- Additions of Acids
- Additions of Bicarbonates or Hydroxides

How to influence Mash pH

- Choose the water you start with
- Depending on the grain bill and base water, mash pH may need to be Increased or Decreased…
- Additions that Decrease pH
  - Calcium Chloride ($CaCl_2$)
  - Calcium Sulfate (aka gypsum, $CaSO_4$)
  - Magnesium Chloride ($MgCl_2$)
  - Magnesium Sulfate (aka epsom salt, $MgSO_4$)
  - Acid Malt, Lactic Acid, or Phosphoric Acid
- Additions that Increase pH
  - Sodium Bicarbonate (aka baking soda, $NaHCO_3$)
  - Calcium Hydroxide (aka slaked lime, $Ca(OH)_2$)
  - Chalk: *avoid …not very soluble at mash temps*

Calcium vs. Magnesium

Calcium and Magnesium decrease mash pH by reacting with Phosphates from the malt. This releases protons (H+ ions), decreasing pH.

- Both Calcium Salts and Magnesium Salts decrease mash pH…which is better?
- Calcium
  - is needed by yeast for flocculation
  - is relatively flavor neutral
- Magnesium
  - is needed by yeast in trace amounts…malted barley has enough
  - can taste sour in high concentrations
- Recommendation: when adding salts to decrease pH or enhance flavor, use Calcium salts rather than Magnesium salts.
  - But which one(s)?

Flavor from Brewing Salts (or ions already in the base water)

- Chloride (Cl_2^-)
  - Richer, "Rounded" Malt Flavor
  - Soft Mouth Feel (compared to Sulfate)
  - Use Sodium Chloride for flavor only (no pH change)
  - Use Calcium Chloride for flavor and to decrease pH
- Sulfate (SO_4^{2-})
  - "Crisp" and Lingering Bitterness
  - Enhances bold hop flavors/aromas
  - Can increase perception of Dryness
  - Use Calcium Sulfate for flavor and to decrease pH
- Sodium (Na^+)
  - Can increase perception of Sweetness
  - Use Sodium Chloride for flavor only (no pH change)
  - Use Sodium Bicarbonate for flavor and to increase pH

Brewing Ion Concentration Ranges: Rough Guidelines

Best concentration for each ion depends on style and personal preference.

Recommended concentrations refer to ions already in the base water (if any) plus ions added by brewing salts. Does not include trace amounts from the grist.

Ppm = parts per million. Equivalent to milligrams per liter.

- Calcium (Ca^{+2}): 50-150 ppm (ales), 10-50 ppm (lagers).
- Magnesium (Mg^{+2}): 0-20 ppm
- Sulfate ($SO4^{2-}$): 0-300 ppm
- Chloride (Cl^{-}): 0-200 ppm
- Sodium (Na^{+}): 0-200 ppm

One Approach to Water Treatment

1) Start with Distilled (or RO) Water and Grain Bill

2) Decide how much Chloride and/or Sulfate is wanted for flavor, and add Calcium Chloride and/or Calcium Sulfate to reach

3) Check if Calcium Level is adequate.

- If yes, skip to 4
- If no, and if mash pH prediction so far is…
  - too high: add more Calcium Chloride and/or Calcium Sulfate to reach desired calcium
  - too low: add Calcium Hydroxide to reach desired calcium
  - right on: add more Calcium Chloride and/or Calcium Sulfate *to the kettle only* to reach desired calcium

4) If the pH prediction so far is…

- too high: add acid malt, lactic acid, or phosphoric acid to decrease
- too low: add Sodium Bicarbonate or Calcium Hydroxide to increase

Q: Sounds Complicated. How Do I "Do the Math?"

A: Use a pH/Water Calculator

- mPH (free)
  - Excellent pH/water calculator by Mark Riffe
  - Easy Interface
  - *Possibly* more accurate than Bru'n Water
  - Includes recommended ion ranges for BJCP styles
  - My choice for best standalone pH/water calculator
  - http://homebrewingphysics.blogspot.com/2016/03/brewing-water-calculator-mph-water.html
- Bru'n Water (free and supporter versions available)
  - Excellent pH/water calculator by Martin Brungard
  - More Complex Interface
  - Possibly not as accurate as mPH
  - Includes recommended water profiles for general color/mouthfeel categories
  - Very popular and long standing calculator
  - https://sites.google.com/site/brunwater/home/files
- BrewCipher (free)
  - Integrated General Brewing Software Spreadsheet by me
  - Pros:
    - Built in mPH model
    - Water sheet is automatically integrated with the recipe/brewhouse parameters (no redundant data entry)
    - Includes recommended water profiles as a starting point for each BJCP style
  - Con:
    - If you just want a water calculator (and not all the rest), standalone mPH would be an easier choice
  - https://www.beeradvocate.com/community/threads/brewcipher-5.553219/

Further Reading

- Bru'n Water Knowledge Page https://sites.google.com/site/brunwater/water-knowledge
- A Homebrewing Perspective on Mash pH I: The Grain Bill (D. M. Riffe) https://www.dropbox.com/s/1y5xbu4uf13mg5g/Effect%20of%20Grist.pdf?dl=0
- A Homebrewing Perspective on Mash pH II: Water (D.M. Riffe) https://www.dropbox.com/s/vkc2smfhbd1705e/Effect%20of%20Water.pdf?dl=0
- A Homebrewing Perspective on Mash pH III: Distilled-Water pH and Buffering Capacity of the Grist (D. Mark Riffe and Mick Spencer) https://www.dropbox.com/s/48x5z49wvsmlkxu/GristpHBuff.pdf?dl=0
- The effect of brewing water and mash composition on the pH of the mash (Dipl. Ing. Kai Troester) http://braukaiser.com/documents/effect_of_water_and_grist_on_mash_pH.pdf
- Water: A Comprehensive Guide for Brewers (John Palmer and Colin Kaminski) https://www.amazon.com/Water-Comprehensive-Brewers-Brewing-Elements/dp/0937381993