Water Chemistry in Brewing

(a presentation by Grant Kinney for Bay Area Mashers on 9 May 2013)

Summary

- What are we talking about in relation to water chemistry?
- What can we control?
- Classic styles and water profiles
- An example recipe

Who am I?

- Not an expert
- Brewing science enthusiast
- Done a little bit of experimentation

Why does this matter?

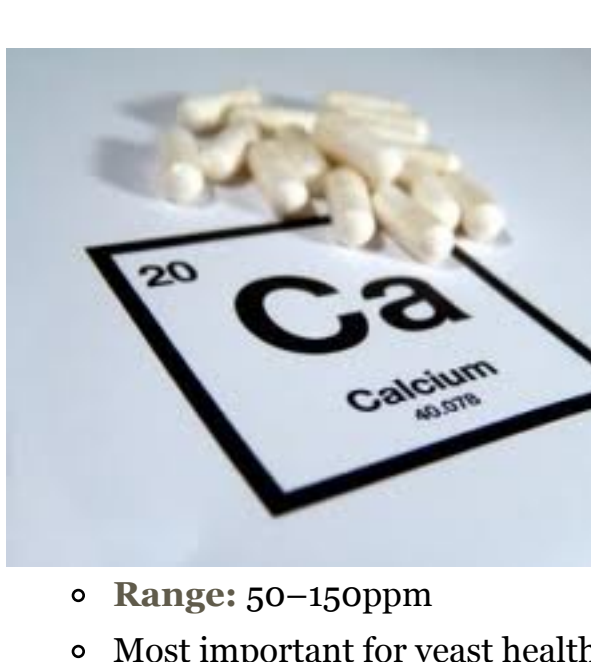
- The evolution of beer styles is directly related to water chemistry
- Control and refinement over desired character of your beer

What exactly do we care about?

- **Mash pH**
    - Effected by **water profile** and **malt color**
    - pH scale
        - 7 is neutral
        - Higher is more alkaline (less acidic)
        - Lower is more acidic (less alkaline)
        - pH of finished beer is ~4
    - Desired mash pH is between 5.2 and 5.8
        - Lower end of range gives more fermentable wort, less body, better extraction efficiency from mash, lighter color, better hot break, and less prone to haze
        - Higher end of range gives less fermentable wort with more body
        - Reducing the amount of water in the mash (thicker mash) will reduce the pH
    - During sparging, we want to keep the pH below 6
    - pH of the water itself doesn't matter as much, because it changes so drastically once you add the malt
    - Note that pH is measured at 25C or 77F (so if you're measuring mash pH, you should cool it down first)
- **Sulfate to Chloride (SO_4/Cl) ratio**
    - Effects perceived **hop bitterness**

What do we look for?

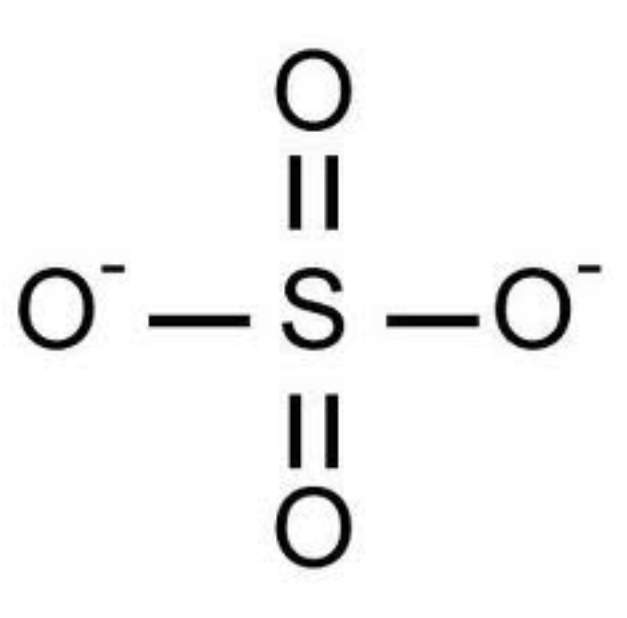
- **Lack of contamination**
    - Would you drink it? If not, don't brew with it.
    - Chlorine
        - Present in East Bay water as chloramine
        - Chloramine is a better purifier, but harder to remove
        - Removing
            - Let it breath–the more surface area open to air, the better
            - Boiling (less effective for chloramine)
            - Carbon filters - effective, but don't force the water through too fast
            - Metabisulfite tablets
            - Use another water source
- **Ions (what's already in the water)**
    - **Calcium (Ca)**



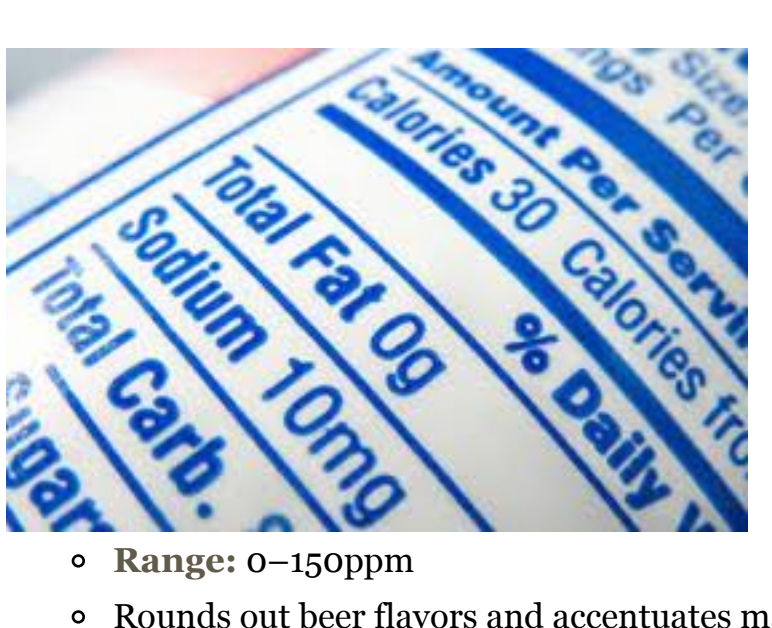
        - **Range:** 50–150ppm
        - Most important for yeast health (generally accepted that you need min of 50ppm)
        - Calcium is what creates hard water
            - When matched with bicarbonates, calcium is "temporary hardness", which can be removed
            - The calcium that remains after boiling is "permanent hardness"
    - **Magnesium (Mg)**

        - **Range:** 10–30ppm
        - Important yeast nutrient in small amounts
        - Minimum of 5ppm for property yeast floculation
        - More than 50ppm tends to give a sour-bitter taste
        - Also contributes to water hardness
    - **Bicarbonate (HCO_3)**

        - **Range:**
            - 0–50ppm for pale, base malt only beers
            - 50–150ppm for amber-colored, toasted malt beers
            - 150–250ppm for dark, roasted malt beers
        - Reducing bicarbonate
            - Boil water, chalk will form on the bottom, decant water off top
        - Bicarbonate (HCO_3) vs Carbonate (CO_3)
            - Bicarbonate has half the buffering capability, but dominates the chemistry of most brewing water because it is the principle form for carbonates in water with a pH of less than 8.4
    - **Sulfate (SO_4 –2)**



        - **Range:**
            - 50–150ppm for normal beers
            - 150–350ppm for very bitter beers
        - Accentuates hop bitterness, making the bitterness seem drier and crisper
        - More than 400ppm can make the bitterness astringent and unpleasant
        - Over 750ppm can cause diarrhea
    - **Sodium (Na +1)**

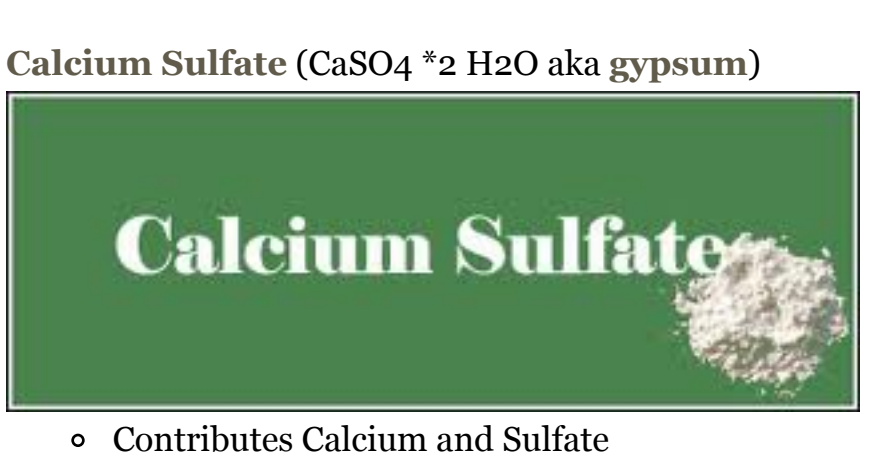


        - **Range:** 0–150ppm
        - Rounds out beer flavors and accentuates malt sweetness
        - More than 200ppm, beer can start to taste salty
        - Combination of sodium with a high concentration of sulfate ions will generate a very harsh bitterness
        - How sodium levels are common in "softened" water that uses sodium to replace calcium
    - **Chloride (Cl –1)**

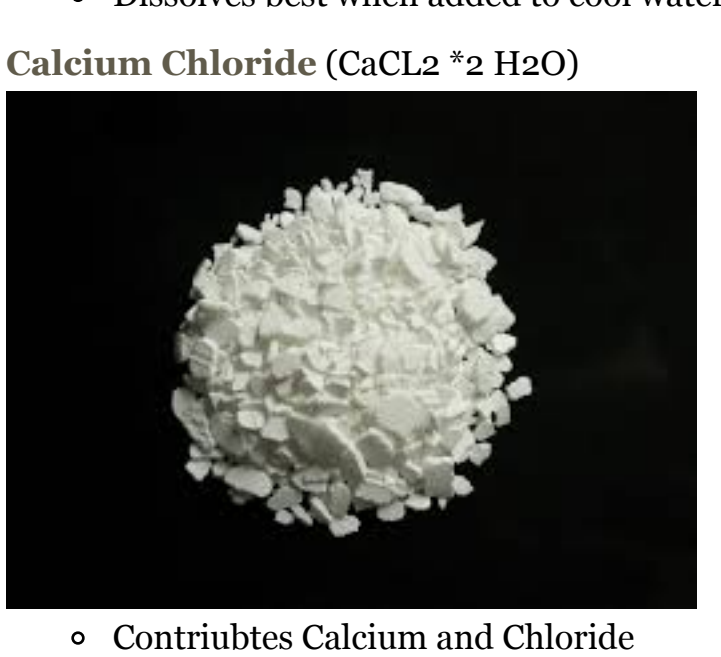
        - **Range:** 0–250ppm
        - Not the same as chlorine
        - Accentuates flavor and fullness of beer
        - More than 300ppm can lead to mediciney flavors
- **Minerals (brewing salts that we can add)**
    - **Raise pH**
        - **Calcium Carbonate** ($CaCO_3$ aka **chalk**)

            - Contributes Calcium and Bicarbonate
            - Doesn't easily dissolve in water–best added directly to the mash
            - Only about half will be dissolved, so double the ammount you actually need
        - **Sodium Bicarbonate** ($NaHCO_3$ aka **baking soda**)

            - Contributes Sodium and Bicarbonate
            - Readily dissolves in water–add directly to brewing liquer
    - **Lower pH**
        - **Calcium Sulfate** ($CaSO_4 * 2\ H_2O$ aka **gypsum**)



            - Contributes Calcium and Sulfate
            - Dissolves best when added to cool water, before heating
        - **Calcium Chloride** ($CaCL_2 * 2\ H_2O$)



            - Contriubtes Calcium and Chloride
            - Readily soluble in water–add directly to brewing liquor
        - **Magnesium Sulfate** ($MgSO_4 * 7\ H_2O$ aka **epsom salt**)

            - Contributes Magnesium and Sulfate
            - Readily soluble in water–add directly to brewing liquer
    - **FiveStar 5.2 pH Stabilizer**

        - Doesn't really work that well
        - Works slightly better in water with high bicarbonates
        - Much better to add appropriate salts as calculated for your water

Tools

- pH meter

- Scale with precision of 0.1 grams

Classic water profiles

- **Note that the charts you find aren't necessarily accurate, or desirable water profiles**
    - Water sources, and how the water was treated, probably varied quite a lot within local regions
- **Pilsen**
    - **Style:** Pilsner
    - **Characteristics:**
        - Low hardness and alkalinity well suited for light malts
        - Lake of sulfate for a mellow hop bitterness
- **Dublin**
    - **Style:** Stout
    - **Characteristics:**
        - High bicarbonate concentration suited for darker, malty beers
        - Low level of sodium, chloride, and sulfate creates an unobtrusive hop bitterness
- **Dortmund**
    - **Style:** Pale lagers
    - **Characteristics:**
        - Less hop character than Pilsners
        - Sodium and chloride bring out a rich malt character
- **Vienna**
    - **Style:** Red-amber lagers
    - **Characteristics:**
        - Similar to Dortmund, but with lower sodium and chloride that accentuate malt flavor
        - Historically, the added more toasted malts to compensate for this
- **Munich**
    - **Style:** Dunkels, bocks, Oktoberfests
    - **Characteristics:**
        - Moderate in most minerals, but a higher in carbonates
        - Low sulfate content provides mellow hop bitterness
- **London**
    - **Style:** Porters and Pale ales
    - **Characteristics:**
        - Higher carbonate level dictated using toasted and dark malts to balance mash pH
        - Chloride and high sodium balanced out flavors
- **Edinburgh**
    - **Style:** Scotch ale
    - **Characteristics:**
        - Similar to London, but with more bicarbonate and sulfate
        - Beers with heavier malt body and fewer hops to achieve balance
- **Burton-on-Trent**
    - **Style:** IPA
    - **Characteristics:**
        - High calcium and sulfate, but balanced hardness and alkalinity
        - High sulfate and low sodium produce an assertive, clean hop bitterness

Don't go chasin' water profiles

(without understanding what about that profile you desire)

East Bay Water

It's great. We really couldn't ask for better brewing water.

EBMUD releases an annual water report. Those who have tested their water have received results very close to the report.

https://www.ebmud.com/our-water/water-quality

Putting it into practice: creating an Pale Ale water profile with East Bay water

Final check

If in doubt?

- Does your water taste or smell bad?
- Does it have chlorine in it?
- Does it have a high level of carbonates?
- What's the hop profile of the beer?

Resources

- How to Brew by John Palmer
- New Brewing Lager Beer by Gregory J. Noonan
- Brewing Better Beer by Gordon Strong
- Principles of Brewing Science by George Fix
- Kai Troester http://braukaiser.com/
- Margin Brungard - Bruin' Water Spreadsheet https://sites.google.com/site/brunwater/