Brewing Water
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Minerals and Brewing Chemistry

• Ionic content comes from soil and rocks in its environment
• Ionic content of brewing water affects mashing performance and flavor perceptions in finished beer
• Ions from these minerals alter water’s
  – PH
  – Hardness
  – Residual Alkalinity
  – Mineral Content
Potential for Hydrogen (pH)

- pH measures the acidity or basicity of water
- Typical municipal water pH is between 6.5 - 8.5
- Raw water pH has modest impact on brewing
  - Alkalinity and mash grist have greater effect on mash pH
- pH of mash influences a number of factors
  - Fermentability
  - Color
  - Clarity
  - Taste
Mash pH

Mash pH of 5.3 – 5.5 optimizes enzyme activity
- Lower end lends toward
  - Fermentability (thin body)
  - Extraction efficiency
  - Lighter color
  - Better hot break
  - Haze resistance
- Upper End lends toward
  - Lower Fermentability (more body)
Mash pH Problems

• Minor increases in wort pH create problems
  – Hop utilization is increased slightly, may lead to coarseness
  – Increased pH slows reduction and removal of diacetyl
  – > 6 = harsh silicates, tannins and polyphenols from the grain
Hardness vs Alkalinity

• **Hardness → Good** / **Alkalinity → Bad**

• Commonly hardness is thought to be undesired
  – Moderately hard to hard water is typically desired for brewing

• Appropriate level of alkalinity is desired in brewing water
  • Alkalinity measures “buffering” capacity of water
    – Ability to neutralize acid and resist pH change
    – Soak up free radical hydrogen ions
      » Higher alkalinity requires more acid to change pH
Alkalinity

- As Brewers, object is to control or reduce alkalinity, not hardness
- Most difficult water to brew with is highly alkaline water
  - Raises mash PH away from target of ~5.2-5.6
Residual Alkalinity (RA)

- Shows the interplay of hardness and alkalinity
- Measure specific to brewing
  - Defines suitability of water for brewing
  - Allows brewer to understand water’s effect on mash chemistry
Residual Alkalinity (RA)

- RA is adjusted in two ways
  - Adjust hardness
    - Reduce RA
      - Add Gypsum, Epsom Salt
      - Boil (remove temp hardness)
      - Dilute with RO / distilled water
  - Adjust alkalinity
    - Reduce RA
      - Add acid (citric, etc)
    - Increase RA
      - Add chalk, picking lime, baking soda
Residual Alkalinity (RA)

How this Water Profile compares to Historic Brewing Profiles (See Red Dot)

Kohlbech's Residual Alkalinity (from A.J. DeLange)

Alkalinity, (mg/L) as CaCO₃

Hardness (Calcium + 0.5 Magnesium), (mg/L) as CaCO₃
Mineral Content

- **Undesirable Ions**
  - Iron – metallic taste, perceptible at >0.3 ppm
  - Manganese – metallic taste, perceptible at >0.05 ppm
  - Nitrate – ideally less than 10 ppm, converts to nitrite in mash (poisons yeast)
  - Sulfide – exhibited as sulfur or rotten egg aroma

- **Desirable Ions**
  - Calcium
  - Magnesium
  - Sodium
  - Chloride
  - Sulfate
# Cation & Anions

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<th>Cation</th>
<th>Low</th>
<th>High</th>
<th>MEM avg</th>
<th>Anion</th>
<th>Low</th>
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<td>N/A</td>
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</table>

**Notes:**

*Should only exceed 150 ppm when beer is highly hopped

^Should be reduced if Sulfate is above 150 ppm
Calcium

- Main ion creating hardness (ideally 50-100ppm)
- Benefits
  - Enzyme activity in mash (reacts with phosphoric acids from grist to lower mash pH)
  - Yeast cell composition (Improves flocculation)
  - Limits extraction of grain astringency
  - Reduces haze and gushing potential
  - Improve wort runoff (efficiency) and improves hop flavors
  - Too little results in beerstone (a type of limescale)
Magnesium

• Next ion creating hardness (ideally 0-30ppm)
• Benefits
  – Accentuates flavor with a sour bitterness at low concentration
  – Yeast nutrition and co-factor for mash enzymes (like calcium)
  – Minimum of 5 ppm for yeast flocculation
Sodium

- Preferred concentration is 0-150 ppm
  - 100 ppm is recommended (save for Gose)

- Benefits
  - Accentuates sour salty flavor at moderate concentrations
    - Poisonous to yeast at high concentration
  - When used with chloride imparts roundness to beer flavor
Chloride

• Preferred concentration is 10-100 ppm
• Benefits
  – Accentuates fullness / sweetness
  – Improves stability and clarity
Sulfate

• Preferred concentration is 0-350 ppm
  – >150 not recommended unless aggressively hopped
  – Kept low when brewing continental lagers with noble hops
    • Dries out bitter perception, may over pronounce malt

• Benefits
  – Accentuates sharpness, dryness and full edge to hi hopped beer
Sulfate/Chloride Ratio

Notes:
- Sulfate accentuates sharp/dry/full highly hopped beers
- Chloride accentuates fullness and sweetness
Bicarbonate

• Strong alkaline buffer responsible for alkalinity
  – Lighter beers – aim <50 ppm / add calcium to reduce RA
  – Darker beers – increase to offset acidity of dark malts in grist

• Benefits
  – Control and adjustment important factor in desirable mash pH