The Quality Guide to Water Chemistry and pH

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Why water? Why pH?

- Two consistently overlooked factors of brewing.
- Water makes up 90-95% of your beer.
- pH is just as important of a metric as temperature is for the brewing process.
  - Example: Beta Amylase: Functions at 140-149˚F AND at pH 5.4-5.6

Water: Role in Brewing

- 90-95% of your beer
- In a brewery, the “water used” to “beer made” ratio is typically 6:1
  - Most water is used in cleaning, brewhouse/cellar operations and packaging
- Has its own unique “flavor profile” and chemically differs from region to region.
- The 3 major areas where water will effect the brewing process is: 1) Mineral Composition/pH, 2) bacterial contamination, 3) inorganic/organic compounds (Flavor taints)
- Professional brewers monitor the following areas:
  - Microbiological Factors
  - Color/Clarity
  - pH (of course)
  - Taste (Chlorination can effect flavor)
  - Heavy Metal concentration (Lead, Slayer, etc are not acceptable in any concentrations in brewing water)

Water: Salts and Ions

	Burton	London	Dublin	Munich	Pilsen	Melbourne
Beer Type	Pale Ale	Mild ales	Stout	Dark lager	Pilsner	Light Lager
Sodium	30	24	12	1	3	4.5
Magnesium	62	4	4	19	1	0.8
Calcium	268	90	119	80	7	1.3
Chloride	36	18	150	1	5	6.5
Sulfate	638	58	15	5	6	0.9
Carbonate	141	123	20*	164	9	3.6
Nitrate	31	3	-	3	-	0.2
Total Dissolved Solids	**1226**	**320**	**320**	**273**	**31**	**25**

* = Bicarbonate (HCO_3)

Water: Salts and Ions

- Calcium (Ca2+)
  - Most important, Compounds added acidify wort, improve extract, FAN levels, better run off, reduced tannins extract, protein precipitation, yeast flocculation, reduced haze formation, protects alpha amylase, strengthens bones, etc. Personally recommend ~80ppm calcium in all brews.
- Magnesium (Mg2+)
  - Enzyme cofactor in yeast
- Sodium (Na+)
  - Improves sweetness, better mouthfeel
  - Too much = Sour flavors
- Potassium (K+)
  - Same as sodium + Flatulence

Water: Salts and Ions

- Iron (Fe2+)
  - BAD: permanent chill haze, metallic off flavor [0.2-0.5ppm], inhibits mash
- Zinc (Zn2+)
  - Yeast nutrient, Cofactor: Too much inhibits yeast.
- Copper (Cu2+)
  - Same as Iron
- Chloride (Cl-)
  - Better mouthfeel, Mellowing flavor. Can help clarification and stability.
- Sulphate (SO4 2-)
  - Better bittering flavors, especially with Zinc.

Tips:

- Monitor the Sulphate to Chloride ratio
  - A key to balancing hop and malt flavors.
  - Example: American IPAs tend to have a 5:1 ratio
- De-chlorinate your sparge/mash water by leaving it out overnight or boiling it prior to brewing.
- The main salts professional brewers use are Gypsum ($CaSO_4$), Chalk ($CaCO_3$) and Calcium Chloride ($CaCl_2$).
- Brewers Friend makes an awesome mash calculator.

pH:

- The Negative logarithm of the effective hydrogen ion concentration or hydrogen ion activity in gram equivalents per L used for expressing acidity and Alkalinity on a scale that ranges from 0 (Acidic) to 14 (Alkaline) with 7 being neutral.
- Remember: When measuring pH always degas your samples. Residual CO2 will throw off your readings.

pH: Role in Brewing

- Just as important as Temperature.
  - Beta Amylase (5.4-5.6), Alpha Amylase (5.6-5.8)
- Mash pH is affected by the Composition of the grain bill, Water treatment, Biological wort acidification and acidulated malt.
- Effects on the brewing process are Physical, Chemical and Enzymatic:
  - Physical: Colloidal Stability
  - Chemical: Alpha Acid Isomerization
  - Enzymatic: Malt-Yeast Enzyme activity

pH: Physical, Chemical, Enzymatic Effects

- Physical
  - Large molecules (Proteins) can become charged thanks to the effects of the wort/beer pH, and thus effect their ability to coagulate, precipitate etc.
- Chemical
  - Isomerization: wort pH of 5.2 = ~60% Hop utilization
  - Color
  - Tannins/Polyphenols are extracted at pH above 7. (Acidify that sparge water)
  - Our Lord and Savior, Calcium, precipitates malt oxalates, at beer pH
    - Also precipitates Cold break more efficiently at pH 5.2
- Enzymatic
  - Bottom Line: Optimal Enzyme pH is 5.2, Optimal Mash pH is 5.4

pH: What exactly am I looking at here?

- Monitor the following areas: Sparge Water pH, Mash pH (10 minutes in), First runnings, Last Runnings, Full Kettle, End of Boil, Knockout.
  - Optimal ranges (<7, 5.4 → 5.0-5.2 → 5.6-5.8 → 5.4-5.6 → 5.2 → 5.2
  - Brewhouse pH can be adjusted by using Acidulated malt and salts.
    - Good points of adjustment would be the Mash, Pre and Post boil.
- During fermentation expect a drop from 5.2 to 4.0, this is due to the yeast creating organic acids.
- Towards the end of Fermentation, the beer pH will rise to about 4.2-4.3. This is due to autolysis and is a good indicator of when to start thinking about racking.
  - If the beer sits longer then 2 weeks, expect the pH to start rising, which indicates more cell death. (bad)
- If possible, Check the pH of your fermenting beer every day.
- Finished Beers with pH Values lower then 4.4 have better stability, head retention, and receive higher sensory ratings.

Summary

- Water is 90-95% of your beer, is used in almost all brewing processes, and its mineral content (which varies regionally) determines its flavor .
- Calcium the über-ion, and all of its ion friends.
- pH is just as important as Temperature
- Mash pH is affected by the Composition of the grain bill, Water treatment, Biological wort acidification and acidulated malt.
- pH control affects the beer on a Chemical, Physical, and Enzymatic level
- Monitoring pH during the brewing process, fermentation process, and after it has been bottled allows for the brewer to determine if anything has gone awry based on deviations from the typical curve.
  - Basically, pH is a litmus test for beer problems.

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