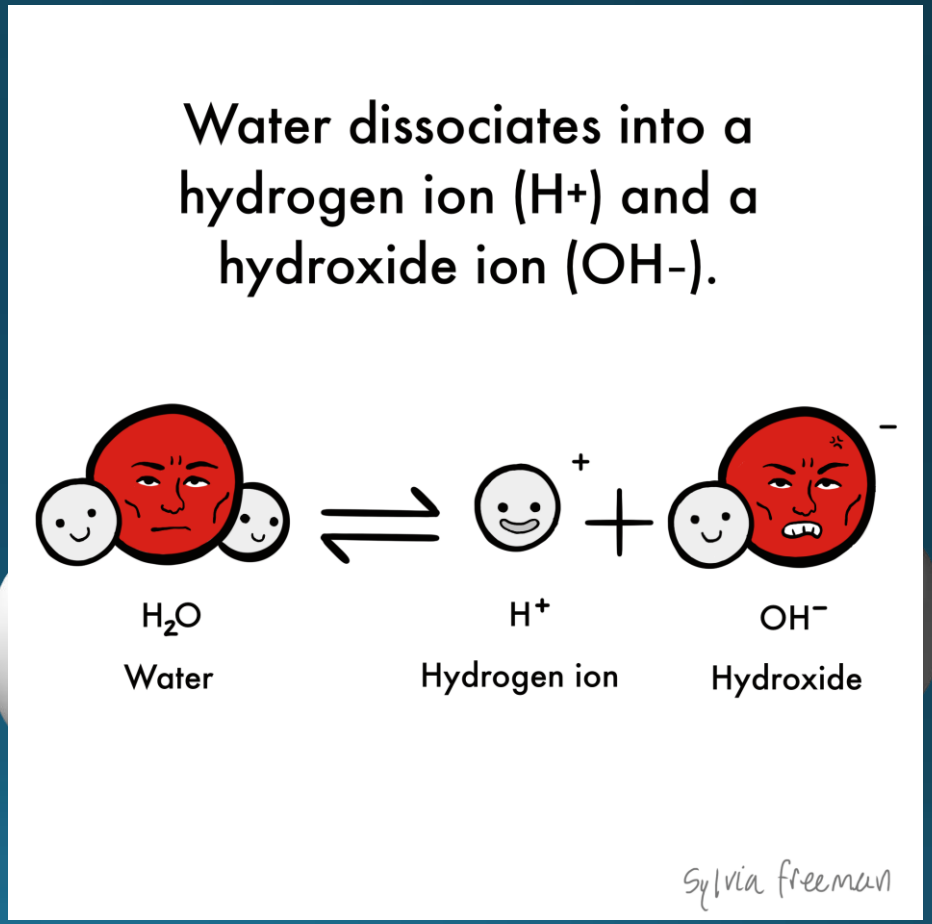
Friends with Beer HBC

Water, water every where

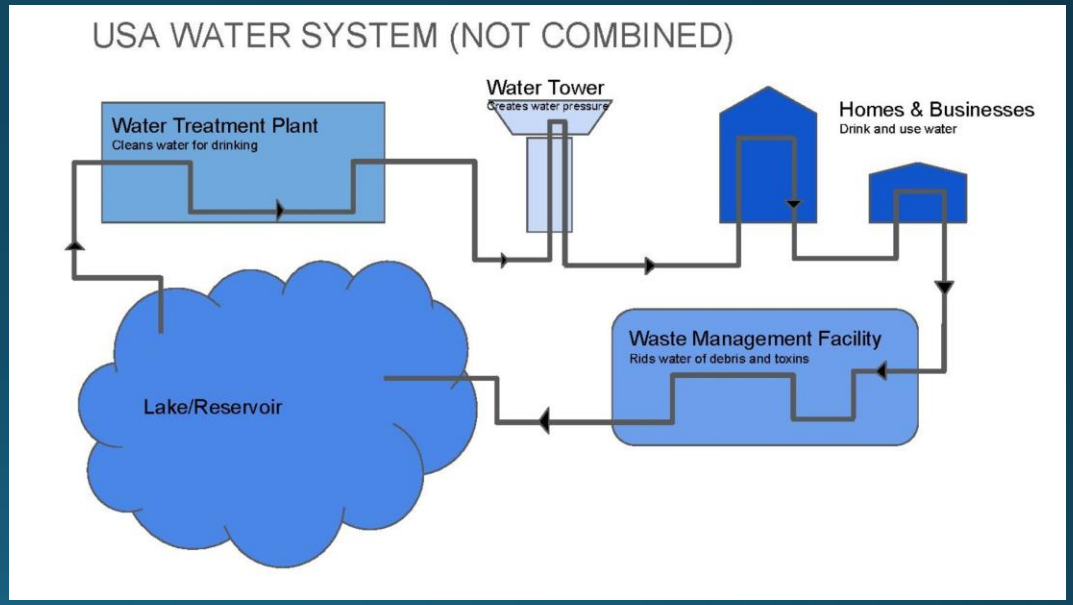
What is Water?

- H_2O (Dihydrogen monoxide)
  - Pure water is colorless, flavorless at room temperature
- The universal solvent
- One of the most important components for brewing good beer
- Adjusting the minerals in water can change a beer



Water Treatment

- DE drinking water comes from groundwater
- Drinking water
  - Contaminant limits are set by the USEPA
  - DPHL offers testing of private drinking water wells
  - Drinking water providers release reports of contaminants
  - Ward Labs – Brewer's test



WARD Laboratories, Inc.

Ag Testing - Consulting

Account No. : 55665

Water Analysis Report

Invoice No. : 1227013
Date Received : 01/17/2017
Date Reported : 01/18/2017

Lab Number : 318

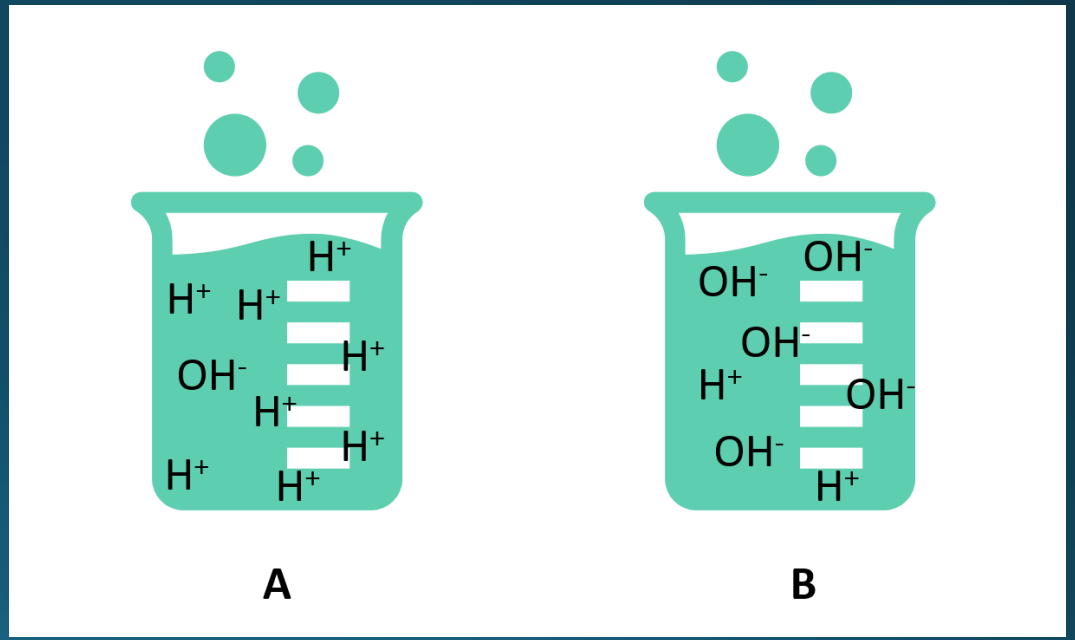
Results For : CHRISTOPHER MAIN
Location :
SampleID :

pH	8.7
Total Dissolved Solids (TDS) Est, ppm	225
Electrical Conductivity, mmho/cm	0.38
Cations / Anions, me/L	3.9 / 4.2
	ppm
Sodium, Na	90
Potassium, K	< 1
Calcium, Ca	1
Magnesium, Mg	< 1
Total Hardness, $CaCO_3$	3
Nitrate, NO_3-N	< 0.1 (SAFE)
Sulfate, SO_4-S	1
Chloride, Cl	16
Carbonate, CO_3	5.9
Bicarbonate, HCO_3	213
Total Alkalinity, $CaCO_3$	183
Total Phosphorus, P	0.13
Total Iron, Fe	< 0.01

"<" - Not Detected / Below Detection Limit

pH

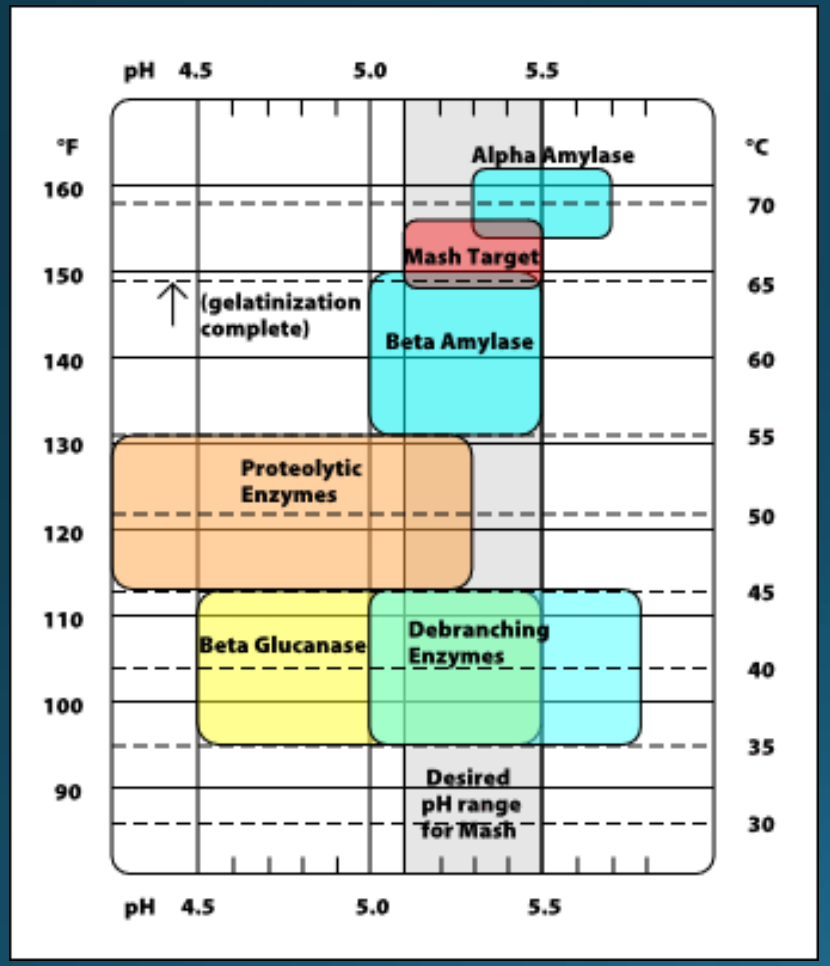
- Concentration of Hydrogen ions in the water
- Higher H^+ - more acidic
- Lower H^+ or Higher OH^- - more basic/alkaline
- Enzymes require a certain range to be effective
- Important for the conversion of starch
  - Optimal range 5.2-5.6 for amylase



Adjusting pH

- Specialty malts
  - The darker the malt the lower it adjusts the pH
- Measuring pH
  - Inexpensive probes are better than paper strips
    - Temperature dependent
      - Higher temperature will raise pH

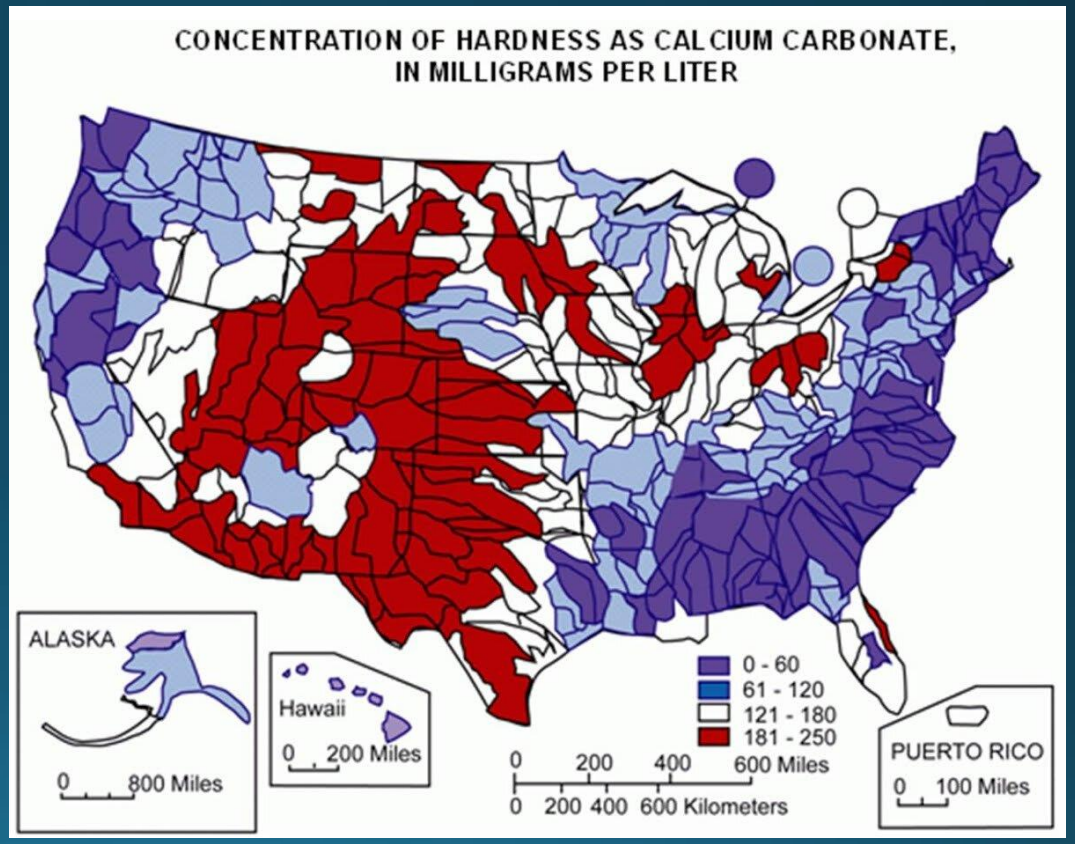
pH



Suggested Mashing pH Targets (room-temperature measurement)	
Beer Character	**Suggested Mash pH Range**
More fermentable wort with less body	5.3 to 5.4
Less fermentable wort with more body	5.4 to 5.5
More sharpness or tartness in beer	5.1 to 5.2
Lighter-colored beers	5.3 to 5.4
Darker-colored beers	5.4 to 5.6
Hop-focused beers	5.3 to 5.5
Malt-focused beers	5.2 to 5.4

Hardness

- The calcium (Ca^{+}) and magnesium (Mg^{+}) content in water, i.e. minerality of water
  - High Ca and Mg content means harder water
- Ca and Mg are both needed for brewing, with Ca slightly more important
  - Will vary depending on style
- Normally noted as $CaCO_3$



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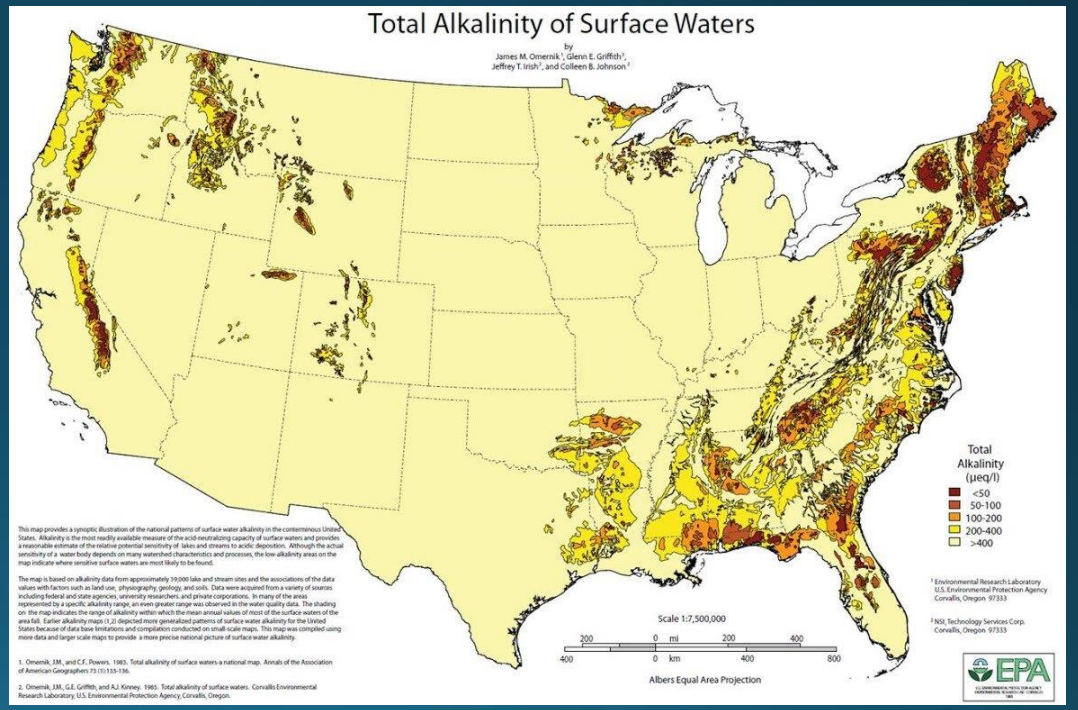
Alkalinity

- The buffering capacity of water
  - How difficult is it to change the pH
- Concentration of carbonate (CO_3), bicarbonate (HCO_3) and hydroxyl (OH^-)
- High Alkalinity
  - Dull flavors, harsh bitterness, darker beer color
- Low Alkalinity
  - Reduce beer body, affect beer flavor



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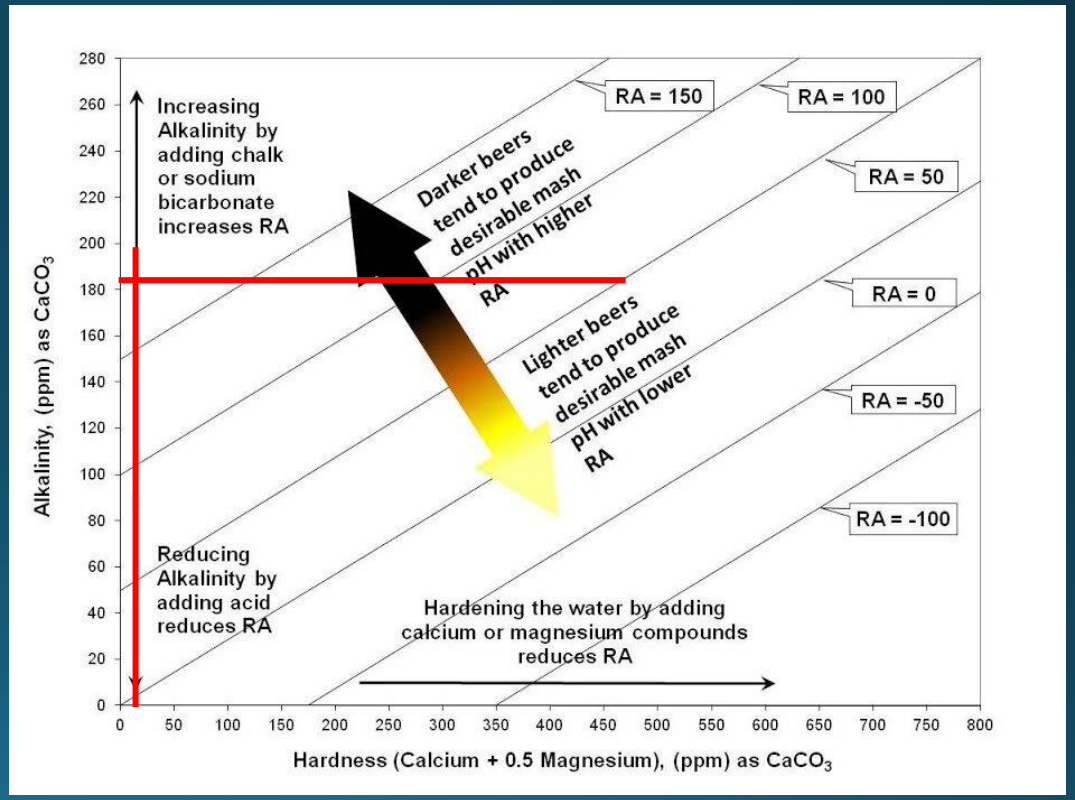
Residual Alkalinity

- Brewing specific value
  - Helps determine potential mash pH
- $RA = Alkalinity - (\frac{Ca}{3.5} + \frac{Mg}{7})$
- RA = ~182



Minerals (Ions)

- Minerals important for
  - Mash performance
  - Flavor perception
  - Suitability of water for brewing
- Cation – positively charged ion
- Anion – negatively charged ion

Ion Effects in Brewing	
Affects Hardness or Alkalinity	**Affects Flavor**
Calcium	Sodium
Magnesium	Chloride
Bicarbonate	Sulfate
	Magnesium

Calcium (Ca^{+})

- Main ion responsible for hardness
- Beneficial for mash and enzyme action
- Yeast composition
- Helps lower the mash pH by liberating H^{+}
- Ideal range 50 to 100 ppm
- Gypsum ($CaSO_4$) or Calcium chloride ($CaCl_2$)

Magnesium (Mg^{+})

- Secondary ion in hardness
- At low levels – adds a sour/bitterness flavor
- At high levels – adds astringent flavor
- Used to help lower mash pH
- Ideal range 0 – 30 ppm
- Above 5 ppm to help aid in yeast flocculation
- Epsom Salt ($MgSO_4$)

Sodium (Na^+)

- Adds a sour, salty taste at modest levels
- Like with cooking, can help with the "roundness" of the flavor
- Ideal range 0 to 150 ppm
- Historic water profiles under 60 ppm
- Gose >250 ppm
- Canning salt (NaCl)

Chloride (Cl^-)

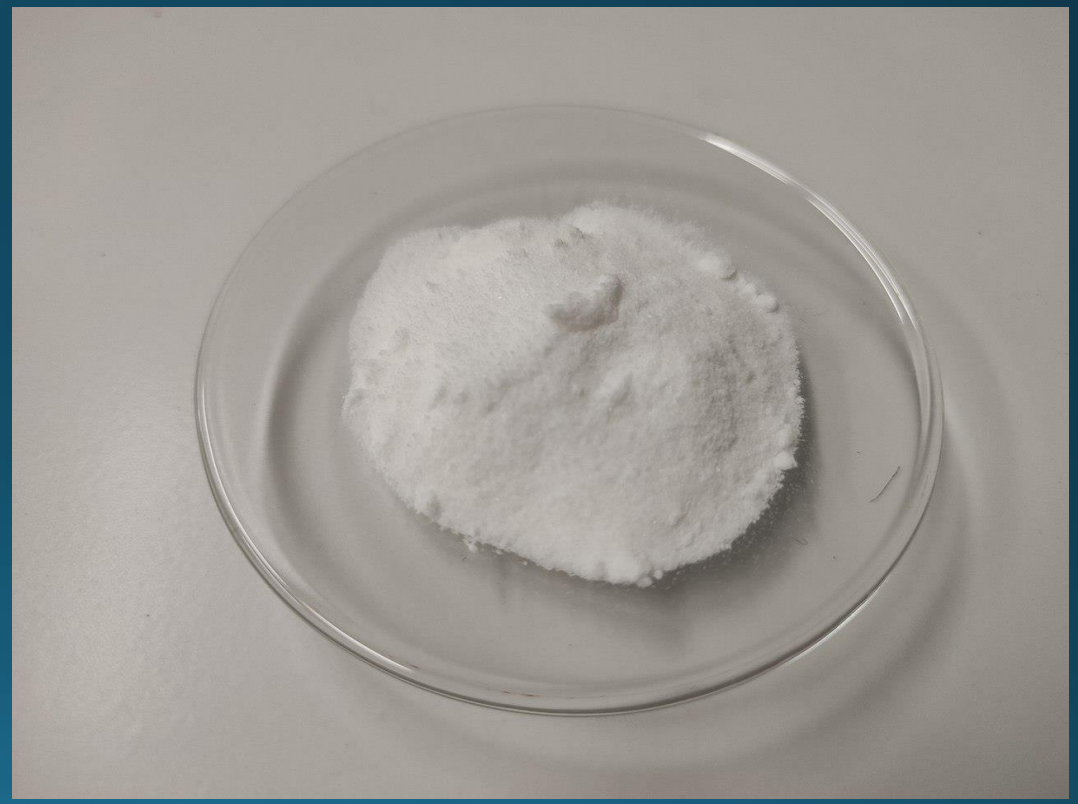
- Accentuates fullness and sweetness
- Improves stability and clarity
- Ideal range 10 to 100 ppm
- High Sulfate, keep <100 pm of Cl^- to avoid harshness or minerally flavor

Sulfate (SO_4^-)

- Provides a sharper, dryer flavor to highly hopped beers
- Ideal range 0 to 350 ppm
- Should not be above 150 ppm unless highly hopped
- Above 350 ppm may produce sulfury odors

Bicarbonate (HCO_3)

- Strongly alkaline
- Mainly responsible for the alkalinity in water
- Malt acids consume most of it during mashing
- Lighter colored beers <50 ppm



Unwanted Ions

- Chlorine
  - If not removed can produce phenolic compounds during fermentation, i.e. band aid taste
- Iron
  - Some iron is required for yeast health but comes from grains
  - Can be tasted as low as 0.3 ppm
- Manganese
  - Metallic flavor at concentrations >0.05 ppm
  - Causes black colored deposits on fixtures
- Nitrate
  - Regulated by the EPA but can be found naturally in groundwater
  - High nitrate can be converted to nitrite during the mash
  - High nitrite is poisonous to yeast

SO_4 to Cl^- Ratio

- Can influence perceived bitterness or maltiness
- Ratio of 2 or greater can enhance hop bitterness
- Ration less than 1 can enhance the maltiness
- 30 ppm SO_4 and 30 ppm Cl is different than a 300 ppm SO_4 and 300 ppm

SO_4/Cl^-

- 0-0.4: Too Malty
- 0.4-0.6: Very Malty
- 0.6-0.8: Malty
- 0.8-1.5: Balanced
- 1.5-2.0: Slightly Bitter
- 2-4: Bitter
- 4-9: Very bitter
- 9+: Too bitter!

Historic Profiles

Ion Profiles for Major Brewing Centers							
Brewing Center	Ion Concentrations (mg/L)						Residual Alkalinity
	Calcium	Magnesium	Sodium	Sulfate	Chloride	Bicarbonate	
Burton	275	40	25	610	35	270	5
Dortmund	230	15	40	330	130	235	20
Dublin	120	4	12	55	19	315	170
Dublin-Wicklow	18	2	13	22	20	35	15
Edinburgh	100	20	55	140	50	285	150
London-Wells	20	5	175	65	125	260	196
London-Thames	40	5	30	70	40	60	18
Munich	77	17	4	18	8	295	180
Pilsen	7	2	2	8	6	5	5
Vienna	75	15	10	60	15	225	125

Other Profiles

Style	Ca	Mg	Na	SO_4	Cl	Bicarbonate	Residual Alkalinity	SO_4/Cl Ratio
Amber (7-17 SRM), Balanced	50	10	15	75	63	40	-9	1.19
Amber (7-17 SRM), Dry	50	15	15	110	50	45	-8	2.2
Amber (7-17 SRM), Full	50	5	15	55	65	35	-10	0.85
Black (>31 SRM), Balanced	50	10	33	57	44	142	75	1.3
Black (>31 SRM), Dry	50	15	33	84	39	145	74	2.15
Black (>31 SRM), Full	50	5	33	35	45	140	76	0.78
Brown (18-31 SRM), Balanced	50	10	27	70	55	90	32	1.27
Brown (18-31 SRM), Dry	50	15	27	99	45	95	33	2.2
Brown (18-31 SRM), Full	50	5	27	50	60	95	31	0.83
Yellow (<6 SRM), Balanced	50	10	5	60	75	0	-40	0.8
Yellow (<6 SRM), Dry	50	15	5	105	45	0	-42	2.33
Yellow (<6 SRM), Full	50	5	5	55	70	0	-39	0.79

Edit Water Profile

Profile Name

Home

Type	Water	pH
Source		8.7

Cations 3.97 mEq/L — ion balance 0%

Calcium Ca^{2+}	ppm	Magnesium Mg^{2+}	ppm	Sodium Na^{+}	ppm
	1		0		90

Anions 4.01 mEq/L

Chloride Cl^{-}	ppm	Sulfate SO_4^{2-}	ppm	Bicarbonate HCO_3^{-}	ppm
	16		3		213

Stats

SO_4^{2-}/Cl^{-} ratio	Hardness	Alkalinity	Residual Alkalinity
0.19	2	175	174

COPY CANCEL SAVE

- Software Demo on Water additions
- Hop-water experiment

Hop Water

- 4 g of hops in 1 gal of distilled water
  - Steep for 6 hours/over night
  - Carbonate 3 1l bottles with a Sodastream
- No Mineral additions
- Dry (i.e. attenuate the hops) – SO_4/Cl of 2.3
  - 0.1 g $CaSO_4$, 0.1g $MgSO_4$, 0.1g $CaCl_2$ in 1 l
- Full (i.e. attenuate malt) – SO_4/Cl of 0.8
  - 0.1 g $CaSO_4$, 0.1g $CaCl_2$ in 1 l

Guess the hop