Brewing Water Made Easy

Roy Roberts, PhD

Goals

- Treat water to remove chlorine and chloramine
- Adjust to desired pH

Water

Apprentice brewers reportedly fined
two pence for using "water" to refer brewing liquor

Straightforward Ideas and Techniques for All-Grain Brewers

water sources and treatment (extract brewers too!)

background / definitions

pH: importance & measurement

mash chemistry

easy!

water sources and treatment

- tap water: treat for chlorine / chloramine and get water report to predict mash pH
- garden hose? use hose suitable for drinking water
- reverse osmosis: own machine or buy water — check with total dissolved solids (TDS) meter
- don't bother buying spring water (has minerals), instead get distilled or reverse osmosis (RO) water

chlorine / chloramine

- chloramine is a more stable version of chlorine & somewhat tougher to remove
- added by municipalities for safe drinking water
  - chlorinated clean water was responsible for massive mortality reductions including three-quarters of the infant mortality reduction, and nearly two-thirds of the child mortality reduction

what's bad about chlorine / chloramine?

- react to make chlorophenol off-flavors perceived at very low levels
- chlorine taste threshold 17 ppm
- chlorophenol taste threshold less than 0.5 ppb (34,000 times lower)
- taste described as medicinal, Band-Aid, antiseptic
- background unpleasantness at low levels

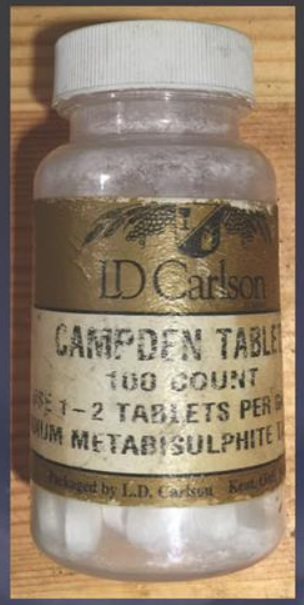
removing chlorine / chloramine

- option 1: Campden tablets
  - about 1/4 crushed tablet per 5 gallons
  - mix with water, reacts immediately
  - chlorine outgassed & remaining products insignificant

- option 2: carbon filtration
  - 10" activated carbon — use a slow flow rate
  - Brita filter? may favorably reduce alkalinity
  - taste output from filter

- option 3: distilled or RO

- treat all tap water in the brew (mash, sparge, top-up). I use both filtration and Campden tablets

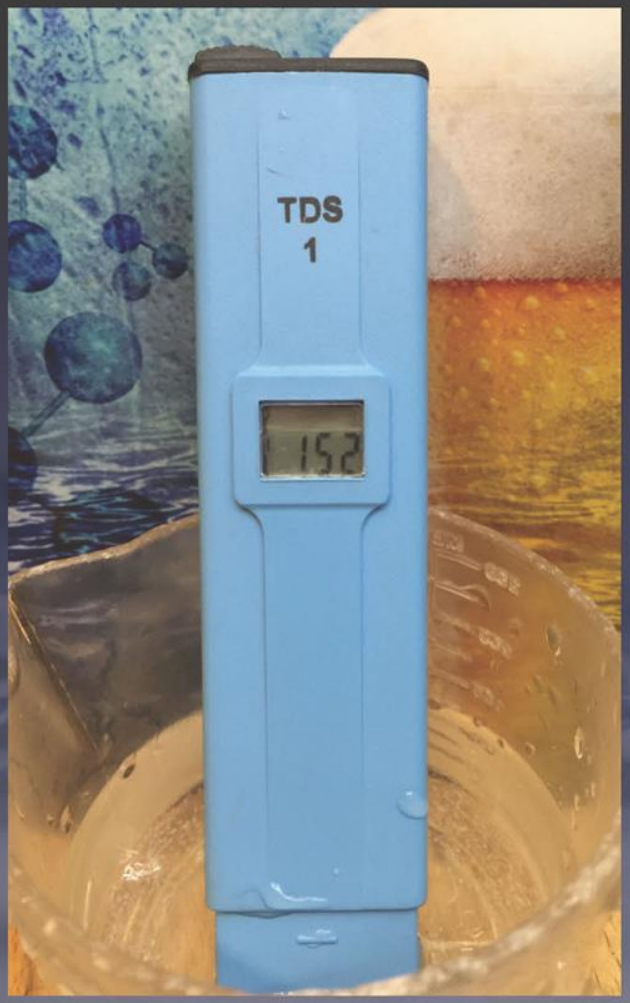


reverse osmosis (RO)

- next best thing to distilled
- strips out almost everything
- about $100 - $200 (+consumables)
- TDS meter to confirm
- probably want to add back calcium for brewing

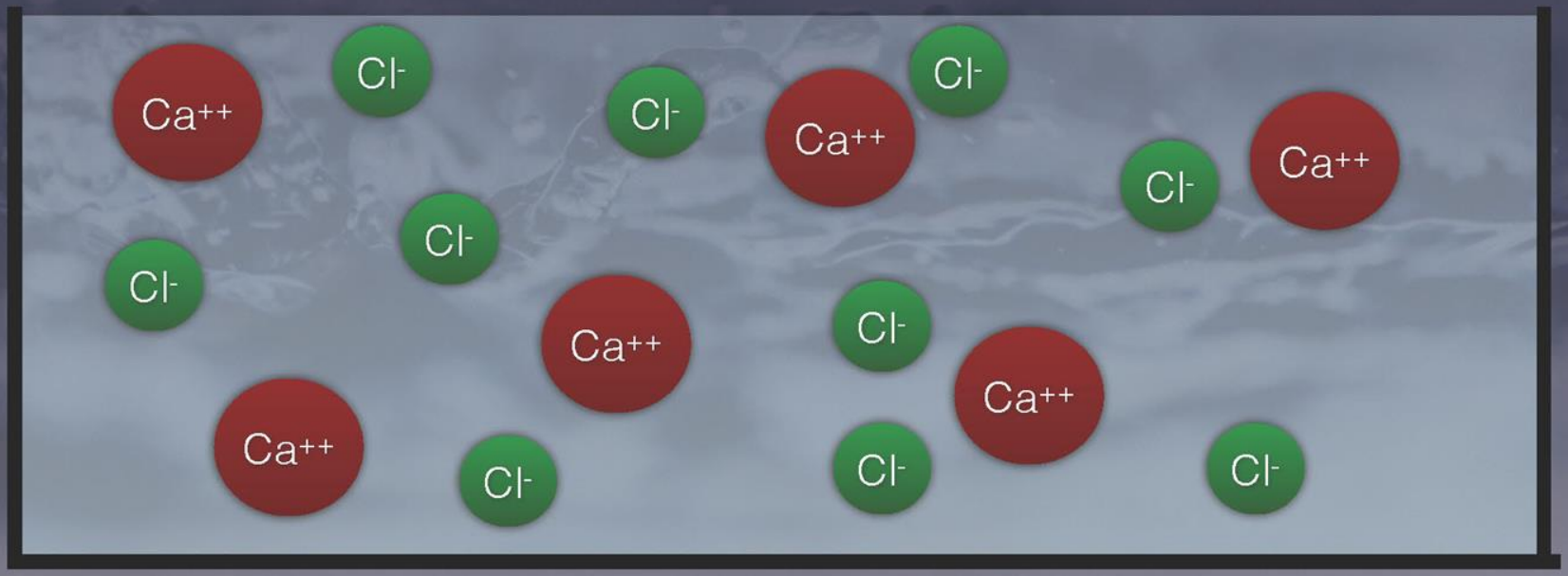
total dissolved solids

- TDS meter measures conductivity as a proxy for dissolved minerals, provides parts per million (ppm)
- distilled water should read 0
- confirm efficacy of RO system (yours or the one at the supermarket)
- after RO, my tap water goes from 230-150 ppm down to ~20 ppm
- TDS meter to check tap water variation?
- about $25



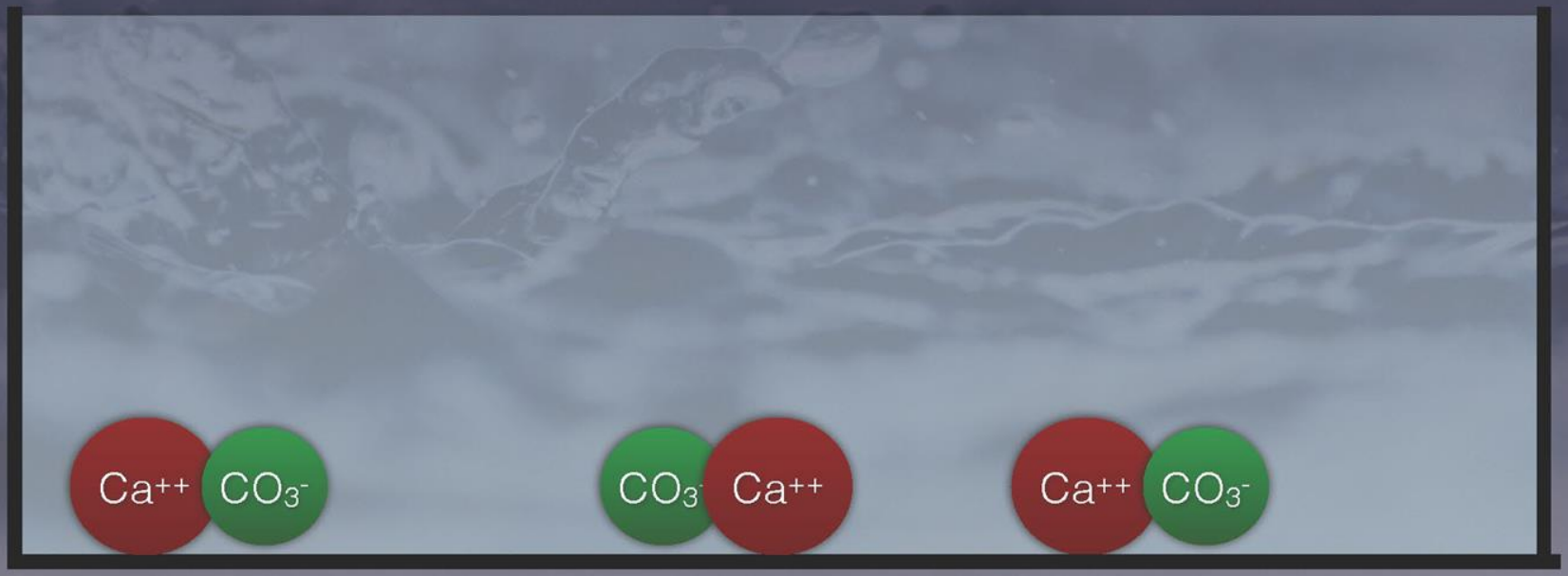
background understanding

- once dissolved water/wort/beer, many easily-dissolved compounds (salts) will split into their components
  - $CaCl_2$ → calcium and chloride ions
  - gypsum ($CaSO_4$) → calcium and sulfate ions
  - Free to react with other dissolved stuff



less soluble compounds

- not dissolved means not available to react
- calcium phosphate compounds form in mash and precipitate ("un-dissolve"), changing chemistry
- $CaCO_3$ (chalk) difficult to dissolve, almost insoluble

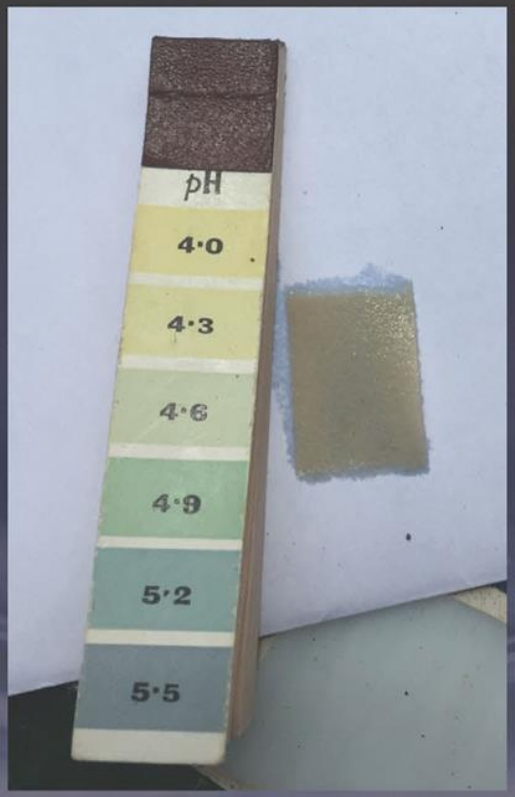


“The most important influence of the dissolved salts in liquor is their influence on the pH of wort and beer.”

Jean De Clerck, A Textbook of Brewing

pH

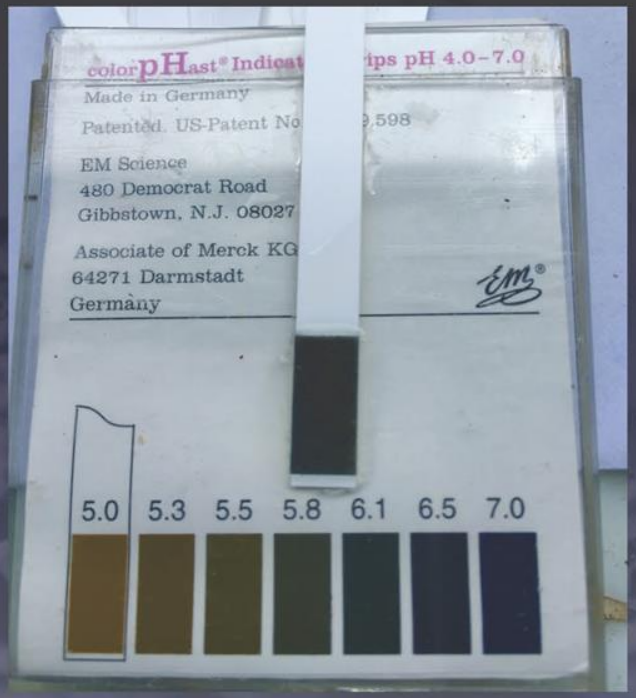
- pH measures acidity
  - lower number = acid
  - higher number = basic, alkaline
  - pure water has pH 7
  - logarithmic: pH 4 is ten times more acid than pH 5



buffering of pH

- Buffering is the resistance of changes to pH
  - example: without a buffer, a few drops of acid might cause pH to drop by 1.0, with strong buffer, could drop only 0.3
  - water is very weakly buffered
  - mash is more strongly buffered
  - pH alone doesn't tell you everything (water pH is almost irrelevant because it will change easily)

why does pH matter?



- with many water sources (hard or alkaline water) and grists (light colored beer), pH will skew high without countermeasures
- elevated pH (insufficiently acidic = too basic) causes problems
  - poor conversion
  - darkening of wort (maybe desirable?)
  - harsh bitterness
  - astringency
  - less resistance to infection

target mash pH

- target mash pH around 5.2 to 5.7
- can adjust between mash & boil, but correct mash vital

mash chemistry

- calcium and magnesium ions react with malt phosphates to lower pH
- thus, the amount of calcium in the mash is critical for determining pH
- example: after mashing in a ten gallon batch, I added 7.5 grams of $CaCl_2$ and the pH dropped from 5.57 to 5.40
- calcium helps amylase enzyme activity

predicting mash pH

- ideally, adjust water before mashing instead of chasing pH during mash
- start with water report
- calculate using
  - spreadsheets: EZ Water, Bru'N Water
  - website: Brewer's Friend "Mash Chemistry" calculators
- different ways of expressing alkalinity and hardness

example water report

Contaminants without Primary MCLs or Treatment Techniques

WATER ENTERING DC WATER'S DISTRIBUTION SYSTEM

Parameter	Units	Average	Range
Aluminum	ppb	41	14 to 103
Bromide	ppm	ND	ND to 0.08
2-Butanone (MEK)	ppb	ND	ND to 9
Calcium	ppm	38	23 to 50
Chloride	ppm	29	16 to 51
Chromium-6	ppb	0.07	0.04 to 0.10
Cobalt	ppb	ND	ND to 0.2
Copper[3]	ppb	3.4	0.5 to 12
Iron	ppb	ND	ND to 10
Lead[3]	ppb	0.1	ND to 0.4
Lithium	ppb	1.9	1.1 to 2.9
Magnesium	ppm	7	1 to 11
Manganese	ppb	0.6	ND to 2.1
Molybdenum	ppb	0.7	0.3 to 1.6
Nickel	ppb	2.0	0.6 to 3.1
N-Nitroso-dimethylamine (NDMA)	ppt	ND	ND to 2.2
N-Nitroso-dibutylamine (NDBA)	ppt	ND	ND to 2.8
Orthophosphate	ppm	2.4	2.0 to 3.0
Perchlorate	ppb	0.5	0.3 to 1.4
Sodium	ppm	20	13 to 29
Strontium	ppb	161	93 to 213
Sulfate	ppm	48	32 to 66
Thorium	ppb	ND	ND to 0.1
Total Ammonia	ppm	0.7	0.01 to 0.9
Total Hardness	ppm	122	72 to 160
Total Hardness	Grains per gallon	7.1	4.2 to 9.3
Vanadium	ppb	0.7	0.1 to 1.6
Zinc	ppb	0.9	ND to 2.2

[3] Results represent levels entering DC Water's distribution system and are distinct from lead and copper compliance monitoring conducted in residential homes.

OTHER WATER QUALITY PARAMETERS— DC WATER'S DISTRIBUTION SYSTEM AND TAP MONITORING RESULTS

Parameter	Units	Average	Range
Alkalinity	ppm	64	45 to 95
Aluminum - Total	ppm	0.008	0 to 0.069
Ammonia - Free	ppm	0.14	0.008 to 0.26
Calcium Hardness	ppm	93	68 to 123
Calcium Hardness	Grains per gallon	5.4	4.0 to 7.2
Chromium-6	ppb	0.07	0.03 to 0.11
Dissolved Orthophosphate	ppm	2.17	1.7 to 3.0
Iron[4]	ppm	0.10	ND to 0.99
Nitrite	ppm	0.02	0.001 to 0.327
pH	—	7.58	7.47 to 7.72
Temperature	Degrees Fahrenheit	67	42 to 89
Total Dissolved Solids	ppm	180	135 to 328

[4] The secondary maximum contaminant level (SMCL) for iron is 0.3 ppm. SMCLs are established by EPA only as guidelines to assist public water systems in managing their drinking water for aesthetic considerations, such as taste, color, or odor. These contaminants are not considered to present a risk to human health at the SMCL.

adjusting mash chemistry

- pre-treat mash water, but measure mash pH to confirm and if necessary adjust during mash
- water manipulation apart from acid/base addition
  - dilute alkaline/hard water with RO or distilled water
  - add calcium salt, normally $CaCl_2$ and/or $CaSO_4$ (gypsum)
  - other salts possible. Mg can work like Ca to lower pH
  - I don't recommend "5.2 stabilizer" (must be some reason it's not called "5.2 pH stablizer")

adjusting mash with acid/base

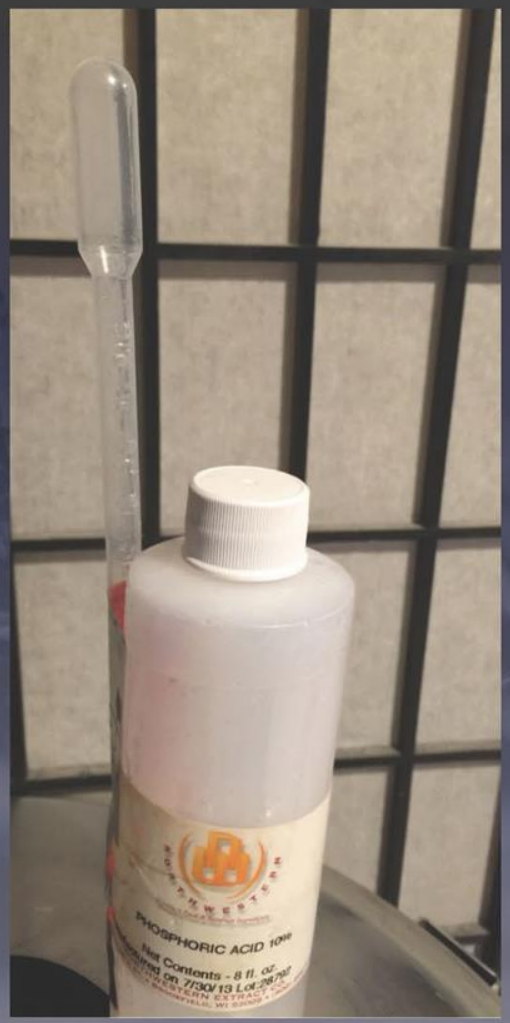
- acid addition - food grade
  - phosphoric, lactic, acidulated malt
  - other acids: citric, sulfuric, HCl?

- base addition for dark beers?
  - chalk (calcium carbonate) almost insoluble
  - baking soda (sodium bicarbonate)
  - calcium hydroxide (pickling lime) - caustic!

mash adjustment goals

- really only need to add Ca, if anything (at least 50 ppm not a bad idea)
- target mash pH at room temperature 5.2 - 5.7
- historical/regional water profiles are available, but beware: brewers adjusted water
- can adjust by style
  - some brewers target higher pH in darker beers
  - water calculator/spreadsheet can guide
- experiment

sparge water treatment



- remove chlorine and chloramine
- acidification can be skipped depending on source water
- if adjusting pH, remember that water is a weak buffer (for filtered DC tap water, I use 5-10ml of 10% phosphoric per 8 gallons)

measuring pH

- pH meter best for actual mash pH
  - why bother? variations in water from report (seasonal and local), variations in malt, personal satisfaction
- cool sample to room temperature
- pH strips have limited accuracy & even the expensive versions are tough to read

shopping for a pH meter

- qualities to look for
  - replaceable electrode (BNC standard or proprietary)
  - two-point calibration (ph 4 & 7)
  - http://www.milkthefunk.com/wiki/PH_Meter
- borrow a meter?

pH meter care and use

- don't abuse with heat
- proper storage solution
- reference standards pH 4 and 7
- no need to calibrate every time, instead check with reference solution
- electrode replacement when slow to respond

salt additions

- US nickel coin is 5 grams to check calibration
- I use mostly RO water and **very** roughly, I will add about 10 grams total $CaCl_2$ and $CaSO_4$ per 10 gallon batch
- salts also impact flavor and can be added post-ferment
  - sulfate accentuates bitterness, chloride sweetness
  - Mg salts, for example epsom salt (magnesium sulfate) - seem unneeded

Further reading

"A Brewing Water Chemistry Primer"
AJ deLange
http://www.homebrewtalk.com/showthread.php?t=198460

Bru'n Water Knowledge
Martin Brungard
https://sites.google.com/site/brunwater/water-knowledge