Simplifying the Complicated Task of Adjusting Your Brewing Water

Brewing water is a complicated topic. The deeper you dig in, the more complicated it can get. For decades now, we have dealt with this problem by recommending that brewers obtain de-mineralized RO water (reverse osmosis) and then add salts back to the water as appropriate to the beer style being brewed. This method is simple, fast, and gets excellent results. If you are brewing 5 gallon batches of extract-based beer, you should most likely stick with this method. But there is a downside. The brewer needs to trek to the store to pick up water in buckets or carboys. For a 10 gallon batch of all grain beer, this can be 15 to 20 gallons of water you need to purchase and haul around. The larger your batch size as a brewer, the less likely you are to find this a great solution. The idea of using your municipal or well water becomes very attractive. Just turn on the hose, and fill up the kettle. Done! But wait, there may be issues with that water as a brewing water source. Generally, using city water requires the opposite strategy of using RO---removing ions rather than adding them. Furthermore, the profile of the water coming out of your tap can vary from day to day. At The Beverage People, our store in Santa Rosa, California, the municipal water was reported to have the following characteristics (2015 report) that are significant to the brewer:

Average pH: 8.14
Total Hardness as $CaCO_3$ (Calcium Carbonate, ppm): 141 – 150
Total Alkalinity as $CaCO_3$ (Calcium Carbonate, ppm): 230 – 240
Calcium (ppm): 27.7 – 29.5
Disinfectant-Free Chlorine (Cl_2) Residual (ppm): 0.01 – 1.46

See any trouble here? I see at least a few problems. For starters, the pH and alkalinity are too high for a proper mash. Next, the calcium levels are below 50 ppm (parts per million, or mg per liter), which is generally considered a minimum level needed for efficient enzyme activity as well as other beer factors such as pH and clarity. Finally, there is chlorine in the water which may be converted in the fermentation into prominent off-flavor compounds called chlorophenols. All these problems will need to be addressed before we can brew with this water. At our shop, we have been working on a simple way to help our brewers address these issues so they can proceed with using their own water.

Before we discuss how to make the needed water adjustments, let's review our goals.

1. Water is the main ingredient in our beer. It should taste good.
2. The alkalinity ion (carbonate and bicarbonate salt) levels in the water have a significant impact on mash pH and consequently on enzymatic conversion, hop extraction, and ultimately the final beer acidity. For mash pH it is generally accepted that the range of 5.1-5.6 is good. Consider that the lower end may be better for some enzymatic activity such as limit-dextrinase, and that the higher end of the range is better for hop isomerization and extraction. For now, let's just say we will be happy to be within the range.
3. Furthermore, we want our sparge water to match this pH, or be at least below 5.8. Should our mash pH rise above this number, we will begin to extract harsh polyphenols from the husks and the wort quality will suffer.
4. Also, we need our calcium levels to reach at least 50 ppm in the mash.

If you'd like to understand these concepts in greater detail, please get a copy of *Water: A Comprehensive Guide for Brewers* by John Palmer and Colin Kaminski.

Now let's address each of these issues. At The Beverage People we have been making use of HACH water quality test strips to check the critical compounds and ensure that we have adjusted them into our ideal range. These strips were recommended to us by Colin Kaminski, brewmaster at Downtown Joe's in Napa, during a talk he gave at our shop. We now stock them. They are very simple to use. With one test strip we can determine the chlorine level, hardness, alkalinity, and pH. For my discussion, I will assume they are being used.

Now taste the water and dip one of the strips. The most common flavor problem we come across is chlorine. It needs to be absent from our brewing water. Leaving the water in the kettle overnight may dissipate the chlorine if the levels are low enough, otherwise carbon or charcoal filtration will be necessary. There should be no prominent iron or sodium levels (water softeners should not be used), or any other flavors that you find objectionable. At a minimum, be sure you cannot detect chlorine on the test strip or by taste before proceeding.

The last time I made use of the water test strips here in Santa Rosa, I obtained these results with untreated tap water: 0 ppm free chlorine, 250 ppm Hardness, 150 ppm Alkalinity, and pH of approximately 8. Compare these numbers to those reported above for Santa Rosa water. You can see that the test strips are in the ballpark, but perhaps not perfect. They are a cheap, easy, but somewhat blunt instrument to use.

Our next critical adjustment is related to pH. Alkalinity above 100 ppm will likely be a problem for our mash. This topic can get very involved. Consider for starters that a mash of only base malt with pure de-ionized water will generally result in a mash pH of 5.6 – 6.0---too high for our liking! Any alkalinity in the water will raise the pH of the mash even further. Therefore, an alkalinity of zero would be nice. Then we can expect that the acidity from any specialty malts will most often be sufficient to bring our pH into the proper range. A lot of black malt may add excessive acidity, so black beers will take special consideration and some level of water alkalinity to buffer the black malt. Since our Santa Rosa water has alkalinity in the 230-240 range, and my test result reported about 150 ppm (after significant storms and flooding in the area), an addition of acid is needed to bring down the alkalinity and reach our target mash pH. While an addition of black malt or acidulated malt will accomplish this, it is difficult to calculate your needs. A more accurate way to accomplish this is with a measured addition of weak acid such as lactic or phosphoric. The Beverage People staff has been working on this topic to make it easier for our brewers. Clare Speichinger and myself recently attended the UC Davis short course on Intensive Brewing Science where professor Michael Lewis discussed water adjustments. Doctor Lewis conducted the program in Brewing Science at the University of California, Davis since 1962. He taught that we must calculate and make our adjustments in terms of milliequivalents (mEq). Once we tackle this concept, the job becomes much easier. So what is a milliequivalent?

Equivalent – An equivalent is the amount of a substance that reacts with (or is equivalent to) an arbitrary amount of another substance in a given chemical reaction.

Milliequivalent - the number of grams of a substance dissolved in 1 mL of a normal (1 N) solution. This is determined by taking into account the valence of the ions.

Once we begin to discuss the alkalinity in terms of milliequivalents and work with acid as a 1 N normal solution, the calculation of the acid needed to neutralize the alkalinity is as straightforward as you might expect when working in the metric system. The prerequisites are:

1. Understand what milliequivalent means.
2. Translate your alkalinity from ppm of $CaCO_3$ to milliequivalents by dividing by 50.
3. Obtain a 1N (1 Normal) solution of lactic, phosphoric, or other weak acid. ***The 1N solution is necessary to make things easy. In the case of a 1N solution, 1 mL of such solution will contain 1 milliequivalent of acid.*** In acid-base chemistry, normality is used to express the concentration of a solution necessary to result in 1 milliequivalent per mL of the required substance. The definition of the equivalence factor varies depending on the type of chemical reaction that is discussed. In our case, we are trying to reduce alkalinity by supplying hydrogen ions to convert all the carbonates and bicarbonates in solution to carbonic acid, and thereby to carbon dioxide gas.
4. Add the appropriate amount of mL of acid to the water.

Let's try adjusting my water as shown above. The strip reported 150 ppm of alkalinity. To translate this into milliequivalents, we divide by 50.

150 ppm Alkalinity (as $CaCO_3$) / 50 = 3 milliequivalents per liter

We can eliminate this alkalinity by reacting it with 3 milliequivalents of acid. If we have a 1N solution of lactic or phosphoric acid, for example, we will simply add 3 mL of acid per liter of brewing water. Stir the water and give it a few minutes to complete the reaction. Test again with a strip and ensure the alkalinity has been reduced appropriately. If you own a pH meter, this would be a good time to check the pH of the water to ensure the pH is acceptable for sparging (below 5.8).

Now that we have good tasting water, with low to no alkalinity, we can begin our mash. Remember that calcium is important, so it is a good idea to add back some calcium to the mash. To add calcium you can use either calcium chloride, which will enhance malt flavors, or calcium sulfate (gypsum) which will sharpen the hop bitterness. Assuming you are treating 10 gallons of water, you will need about 7 grams (about ½ Tbsp) of calcium chloride or 8.5 grams (just over 1/2 Tbsp) of calcium sulfate to achieve 50 ppm.

This is only one scenario, the most common we experience here in Santa Rosa. Sometimes your water may require a reduction of hardness, or perhaps an increase in alkalinity. To be ready for all scenarios, I'd recommend you stock some of these items in your brewery:

Water: A Comprehensive Guide for Brewers by John Palmer and Colin Kaminski.
HACH Water Quality Test Strips
pH meter with calibration solutions (4 and 7 pH)
1 N solution of lactic or phosphoric acid
syringes, graduated beakers and cylinders, as needed for measurements
Brewing water salts – Calcium Chloride, Gypsum, Chalk

It will take some time to master these concepts, but you can do so from the comfort of your own home without hauling buckets to the grocery store!