COMPLIMENTARY

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A Look at pH and Alkalinity

James W. Fatherree, M.Sc., Science Instructor, Hillsborough Community College, Tampa, FL

Maintaining an acceptable pH and alkalinity is particularly important when keeping organisms like corals that use calcium carbonate to produce skeletal material.

When it comes to creating and maintaining an appropriate environment for keeping marine organisms, it's critical to keep the pH and alkalinity within acceptable ranges. Fortunately, this is possible without needing an in-depth understanding of what pH and alkalinity are, but it's always nice to know a little more than the bare minimum. So, I'll give you a basic explanation of what each of these is, and how to keep them in check.

Let's start with the basics. A water molecule is comprised of two hydrogen atoms and one oxygen atom (H_2O), but here we need to think of water as being a mixture of hydrogen ions (H^+) and hydroxide ions (OH^-). The abbreviation "pH" stands for *pondus hydrogenii*, which is Latin for "quantity of hydrogen." So, pH obviously has something to do with these hydrogen ions.

Now if you think about it, it's easy to see that in any volume of perfectly pure water, there would be an equal proportion of hydrogen and hydroxide ions, with one H^+ for every OH^- present. It would also have a pH of 7 due to this balance, which means it's neutral. There are all sorts of things in aquarium water though, from salts to dissolved gases, and these can change the balance between H^+ and OH^-. As such, substances intermingle with the water molecules; they may react with the H^+ and/or OH^- and cause the relative concentrations of

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the two to change. And that is how water becomes acidic or basic.

Basically, hydrogen ions act as an acid, and if the concentration of H^+ is higher than that of OH^-, we call the solution acidic and give it a value less than 7. Conversely, if the concentration of H^+ is less than that of OH^-, which acts as a base, we call the solution basic (or alkaline) and give it a value greater than 7. In general, the scale uses ranges from 0 to 14, so these numerical values give us an idea of how out of balance the H^+ and OH^- are.

It is also important to note that the 14-point scale is a logarithmic one, meaning that each number is actually representing a change that is ten times greater or less than the next. Thus, water with a pH of 10 really has 1/10 as much H^+ as water with a pH of 9. Likewise, water with a pH of 3 has 10 times more H^+ than water with a pH of 4.

Seawater typically has a pH of around 8.2 due to all of the solids dissolved into it. However, carbon dioxide (CO_2) can have a strong effect on its pH, too. As CO_2 dissolves into water, most of it reacts with the water and forms a weak acid called carbonic acid (H_2CO_3), which causes the pH to go down and head more towards the acidic side of the scale. If it's allowed to build up in the water, the pH will continue to go down and this can cause real trouble for any inhabitants. Conversely, the removal of CO_2 can also cause the pH to rise higher than 8.2, becoming more and more basic. For these reasons, it is not uncommon to see the pH in an aquarium swing from as low as the upper sevens to as high as the mid eights, especially in those that have any sort of algae in them (including the algae living inside corals). As long as it stays between the upper sevens and the upper eights, you shouldn't lose anything, but if you want to keep everything as healthy as possible, you'll want the pH to stay between 8.2 and about 8.4.

Various sorts of algae take CO_2 out of the water as they perform photosynthesis, driving the pH up during the day. And, when the lights go out at night and photosynthesis stops, the concentration of CO_2 can go right back up, making the pH go back down. However, vigorous water movement promotes better gas exchange with the atmosphere, which can help keep the concentration of CO_2 from either increasing or decreasing very much and causing the pH to reach dangerous levels in either direction.

There's also the potential for a slow but steady buildup of weak organic and nitric acids in closed aquarium systems to have an effect of pH. However, this change is in the form of a slow drifting toward a lower pH, rather than a day-to-night swing up and down. Fortunately, partial water changes can usually keep this from becoming an issue. Now, it's time to look at alkalinity.

Alkalinity, in the simplest terms, is a measure of water's ability to resist changes in pH, which can be affected by a number of substances dissolved in it. In that mix of H^+, OH^-, CO_2, and H_2CO_3, we can also find carbonate (CO_3) and bicarbonate (HCO3), which are obviously comprised of the same intermingling constituents and can also play a significant role in pH changes. This is because CO_3 and HCO_3 act as buffers, which have the ability to neutralize acids. When they're found in quantity, the water will strongly resist downward pH changes, but if they're depleted, the pH can change more, and faster. Some other substances, like borate, hydroxide and sulfate, can also act as buffers, but these have a minor effect on alkalinity relative to that of carbonate and bicarbonate.

This is very important, as marine environments typically have an exceptionally stable pH. So, the organisms that live in the sea are used to a specific pH range, and they generally won't tolerate rapid and/or

Any sorts of algae in an aquarium will affect the pH through their photosynthetic activities, making it go down during the night when the lights are out and carbon dioxide uptake decreases.

broad changes in pH very well at all. Corals, clams, and other organisms that use calcium carbonate ($CaCO_3$) also depend on the presence of carbonates, as they're used along with calcium to build their skeletons/shells. Thus, it is imperative that you keep the alkalinity up.

How high it should be maintained depends on the scale that is used, though. Alkalinity is usually reported as milliequivalents per liter (meq/L) and refers to the amount of acid that would have to be added to water to totally deplete all of the buffers in it. However, alkalinity is also commonly reported in degrees of carbonate hardness (dKH, as carbonate is spelled with a k in German) and refers to the amount of acid that would have to be added to water to totally deplete only the carbonate buffers. Typically, the amount of acid needed to do either would be about the same, so we don't need to worry about the slight differences in the two. That's why the term "carbonate hardness" is often used synonymously with alkalinity, despite the fact that carbonate hardness only accounts for the buffering ability of carbonates.

Natural seawater typically has an alkalinity of about 2.5 meq/L, which is the same thing as 7 dKH (to convert from meq/L to dKH, just multiply by 2.8). However, because aquariums are closed systems, it is best to maintain a higher alkalinity in order to counter the constant production of acids. Thus, while opinions may vary a bit, I think you should try to keep it in the range of 2.5 to 4.3 meq/L, which equates to 7 to 12 dKH. The middle of this range has worked very well for me for many years, and I haven't seen any problems at the ends of this range, either.

Fortunately, it can be fairly simple to keep alkalinity within these ranges, as there are a number of commercial buffers available, which come in powdered form and only require that you perform alkalinity tests and then follow the directions to adjust it accordingly. You can also use one of the many brands of two-part calcium additives that are available. One part of these products contains concentrated calcium for organisms to use, and the other part contains buffers for maintaining alkalinity. So, using them does two jobs at once. Of course, you should always read the directions for any such product and make sure to follow them to avoid any overdoses.

Likewise, you can use limewater, which is commonly called kalkwasser. This stuff is made by mixing powdered calcium hydroxide ($Ca(OH)_2$) with water, making the calcium available for organisms to use and the hydroxide available to neutralize acids. The only problem is that it has to be made up regularly, used promptly, and will cause serious problems if added to an aquarium too quickly. Limewater typically has a pH greater than 12 due to the high concentration of OH^-, so it should be obvious that adding a lot at one time can cause a rapid rise in pH that may be intolerable. Thus, it should be added very slowly, by using a drip/dosing system if possible.

Also note that it has to be used promptly due to the effects of atmospheric CO_2. As it slowly and inevitably dissolves into the limewater, it causes the pH to fall, and that makes some of the calcium precipitate out in the container it's in. So, the longer it sits, the weaker the solution gets. Still, I've been using it for years, and it's not much of a chore to dose it regularly. I just mix up a little at night before going to bed and use a drip bucket that I made to add it to my aquariums the following morning. Keep in mind that this can also be overdone, so again, be sure to follow the manufacturer's directions.

And that's it. I hope you have a better understanding of these two water quality parameters now, and how to keep them where they should be.

A CONTINUING SERIES

Parts 7, 8 and 9: Science Behind Synthetic Sea Salts

From the Labs of Instant Ocean

Visit www.instantocean.com to read the earlier installments of this continuing article.

OUTLINE

7. Using Marine Sea Salts in Fresh and Brackish Water Aquaria

Instant Ocean can also be used in fresh and brackish water aquaria. Many fish, such as goldfish and livebearers, do better in water with a little salt in it. The salt concentration in these tanks is usually 1 to 3o/oo (in contrast to NSW which is 28 to 35o/oo).

Brackish water aquaria have a salt content from 10 to 20o/oo, in general. Scats and some puffers do well in these types of tanks. Instant Ocean is perfect for this application.

8. Conclusions

Instant Ocean is the premier synthetic sea salt in the world. This claim can be substantiated by these facts:

- Instant Ocean in used by more public aquaria around the world.
- Instant Ocean is cited in more scientific papers than any other synthetic sea salt.
- Instant Ocean is used by more marine aquarium hobbyists than any other sea salt.

For the past forty-plus years, the goals of Instant Ocean have been to produce a synthetic sea salt that not only mimics natural seawater, but also contains additional amounts of critical ions; and to provide a sea salt that not only maintains marine organisms in top condition, but also provides an environment that promotes the spawning and rearing of these organisms. From the start, Instant Ocean was developed and refined by scientists and aquarists with a devotion to marine organisms and aquaria. That devotion continues today. There is nothing better for your fish and invertebrates to live in.

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PUBLICATION INFORMATION

SeaScope® was created to present short, informative articles of interest to marine aquarists. Topics may include water chemistry, nutrition, mariculture, system design, ecology, behavior, and fish health. Article contributions are welcomed. They should deal with pertinent topics and are subject to editorial reviews that in our opinion are necessary. Payments will be made at existing rates and will cover all author's rights to the material submitted.

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