

Water Clarity

By Bob Lowry
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Of all the aspects of water care, one of the most important things for many people's "piece of mind" is water clarity.

Crystal-clear, sparkling water requires a long-enough filter cycle to make sure all the water has been filtered, enough sanitizes to kill, oxidize or burn up all the living things in the water and a filter that is capable of removing large-size particles and debris that may enter the water as well as remove the tiny microscopic things.

Scientifically, small particles are measured in "microns". A micron is one millionth (1/1,000,000) of a meter. To give some perspective, a grain of table salt measures between 90 and 110 microns across; a grain of talcum powder is 5-10 microns across. The naked human eye can see down to about 35 microns.

E. Coli bacteria, commonly counted by researchers to judge the effectiveness of water sanitizers, measure between 1 and 4 microns. While that may seem small, there are some particles that are even smaller than a micron - coal dust, for example. It takes 250 particles of coal dust combined to measure 1 micron. The particles are so small that they are barely affected by gravity, and when put into water, they don't even sink. It has been estimated that it would take 63 years for one of these tiny particles to sink the distance of just one foot in water.

Little, tiny particles suspended in water that are smaller than a micron are called colloids, or colloidal particles, and are extremely difficult dealing with when it comes to maintaining water clarity.

Because they are so small, they can pass right through any filter. Because they are not affected by gravity, they simply remain suspended throughout the water. And since they reflect light, they make the water look murky and cloudy even though you can't actually see them.

One interesting thing about colloids is that just about all of them are negatively charged. This is an important fact to remember, because negative charges repel each other and therefore can't combine or neutralize one another.

Colloids are not the only thing that can make water look murky. The water can also look cloudy because there are things growing and multiplying in it. Bacteria that are 1 to 4 microns in size are capable of multiplying into literally millions in just a few hours if not controlled. Keeping enough sanitizer to kill and control living things in the water is important and will keep the water clear. However, once you have killed the organisms, you still need to get rid of their little, tiny skeletons that are still present in the water.

On top of these, there are the things that the bathers bring into the water with them. Things like soap, body oil, deodorant, hair spray, body lotion, hand, cream, perfume, cologne, makeup, lipstick, suntan lotion, sweat, etc. Plus environmental contaminants: like pollen, grass clippings, fertilizer, dust storms,

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rain storms, salt air, smog, jet fuel, brush fires, forest fires, acid rain, insects, rodents, dogs and cats - all of which can cloud and discolor water.

Proper filtration forms a major line of defense against murky water. But even the best filter cannot do the total job.

What Does A Filter Filter?

There are three primary types of filters used in the pool and spa industry: sand, cartridge and diatomaceous earth (DE). These are different from one another not only in the substances they use to filter the water (called the filter media) but also in the size of particle they are capable of trapping.

Here are some brief descriptions of how the three major types of filters work and their effectiveness at removing small particles. The sizes given are approximate and are based on a new or freshly charged filter. Some manufacturers may use slightly different figures, and you should also realize that as a filter loads up with contaminants, its ability to trap small particles actually increases.

- Sand filters use a special filter sand (normally .45 to .55 millimeters in size) to trap suspended particles. These filters are normally capable of trapping particles 25 to 30 microns in size.
- Cartridge filters use a tightly woven polyester cloth to trap suspended particles. These are normally capable of trapping particles 8 to 10 microns in size.
- DE filters use the fossilized skeletons of microscopic plants called diatoms to trap suspended particles. Each diatom skeleton is honeycombed with hundreds of microscopic channels which are normally capable of trapping particles 1 to 3 microns in size. Most would agree however, that a D.E. filter will trap a 1-micron-sized particle.

It should be clear that none of these filters is able to trap a particle smaller than 1 micron -unless it's very dirty, in which case, you would have very little water flowing through it and therefore, no circulation. Obviously, the filter needs some help in order to obtain water clarity.

Making It Perfectly Clear

Think about this for a moment: If a filter cannot trap a particle smaller than 1 micron, and you had thousands of tiny particles (smaller than a micron) floating in the water, what would you do? One suggestion might be to glue together a whole bunch of those tiny particles until they formed a large particle, capable of being captured by the filter. That is the principle behind water clarification. The idea is not new, but the way we do it today is strictly the product of modern science.

Man has been trying to clear murky, cloudy or turbid water for thousands of years. In the early days of recorded history, various natural materials such as crushed almonds and beans in Egypt and nuts in India - were used to clarify water.

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Those ancient folks used to store drinking water in metal or clay pitchers, throw in some nuts or beans and wait for the water to become clear. The impurities would glom on to the nuts or beans and settle to the bottom. They would then skim off or strain the water out of the pitcher and drink it.

This form of clarification used a principle called agglomeration, because the impurities glommed or clumped together before they settled. Individually, the tiny particles in the water were not heavy enough to be affected by gravity. But once they were agglomerated, they were heavy enough to settle. This process is also called coagulation, because the dissolved particles form a clot and fall to the bottom of the water.

The ancient Chinese found that they could clarify water quite effectively by using a natural chemical salt, which scientists in the 19th Century identified as aluminum sulfate, more commonly known as alum.

In 1843, an English scientist named James Simpson used alum experimentally in municipal drinking water. Another scientist, Isaiah Hyatt, was granted a patent in 1884 for the use of alum to coagulate suspended particles in drinking water prior to filtration. A pair of municipal companies in New Jersey were first to use alum in the United States, in 1885. The same technology is still in use today by many water companies throughout the world.

From the time it was first introduced in the United States, it took about 30 years for the swimming pool industry to get wind of alum as a water clarifier. The industry began using alum after World War I, and many pool service people continue to swear by this 100-year-old technology (5,000-year-old technology if you're Chinese).

The ancient Chinese didn't understand exactly how alum worked. They only knew that it worked. Today, we realize that when alum is added to water, it forms a gel-like precipitate of aluminum hydroxide that bridges or sticks together, forming small bundles (called flocs) that trap suspended particles as they fall through the water.

This process is known as flocculation. It creates a large amount of sediment on the bottom of the pool, made up of both the gel-like alum precipitate and all the suspended particles and oil that were in the water. This is usually vacuumed rather than filtered out because it is usually more than the filter can handle.

Incidentally, there are several metallic salts that work exactly like alum but aren't actually alum (aluminum sulfate) - such as ferric (iron) sulfate, ferrous sulfate and ferric chloride. Manufacturers of products containing these salts are free to proclaim that their products "contain no alum," although they work in exactly the same way as alum and produce the same heavy sediment.

For alum to work properly, the pH of the water needs to be adjusted to near 8.0. At a higher pH, the floc is fairly unstable and wants to come apart. At a lower pH, the floc can easily dissolve in the water.

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When alum is added to the pool water, it actually uses part of the water's total alkalinity to form the gel-like aluminum hydroxide floc. Therefore, when you use alum, it will reduce the total alkalinity.

The pH of a 1-percent solution of alum is 3.4 - it is highly acidic. Therefore, it will lower the pH of the water.

Although recommendations vary, the best estimates that I have are to use somewhere between 4 and 12 pounds of alum per 10,000 gallons of water. This is usually broadcast over the water's surface.

Assuming that you use the low dosage rate of 4 pounds per 10,000 gallons, it would lower the pH by 1 full pH unit, and it would lower total alkalinity by 40 parts per million (ppm). Once the alum flocs have been vacuumed to waste, you will have to adjust the pH and total alkalinity up to their recommended levels.

Polymers

Just as it took 30 years for the use of alum to be accepted by the swimming pool industry, it also took a long time for the industry to be introduced to the use of organic polymers for water clarification.

A polymer (pronounced "POL-imer") is a huge molecule that contains many repeating parts. Poly means "many;" mer means "part." Wood, hair and rubber are natural polymers. Humans have imitated these natural polymers in synthetic polymers that have many different uses.

Synthetic polymers form the basis of our modern plastics industry. The process of forming a polymer (called polymerization) was developed in Germany in 1922 by a scientist named Hermann Staudinger. In 1945, organic polymers were first used to clarify water. But it was not until around 1970 that polymers were introduced into the pool industry.

The polymers that we use in water clarification are called organic because they contain the element Carbon. If we were to look at a polymer through a high-powered microscope, it would resemble a long chain of repeating units.

To make it a bit clearer, try picturing a chain in your mind. It can be a necklace, an ID bracelet or a chain used to tow your car. Each link of the chain is a unit and is identical to all the other links. Chemically, a polymer is a chain of identical, repeating units called monomers. The prefix mono means "single."

How do organic polymers work to clarify water? To understand this, we need to define a few more terms.

First of all, you need to know that polymers used for water clarification depend on tiny electrical charges to do their job. There are many chemical substances - called electrolytes that, when you dissolve them in water, come apart or dissociate into electrically charged parts, called ions. This process is called ionization.

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Ions can be either positively or negatively charged. Positive ions are called cations (pronounced "KAT-ions"). Negative ions are called anions (pronounced "AN-ions").

Each link of an organic polymer can ionize, so an electrically charged polymer is called a polyelectrolyte. If it has positive charges along its links, it is said to be cationic. If it has negative charges along its links, it is said to be anionic. (Just in case you were wondering, if it has both positive and negative charges along its links, it is said to be ampholytic.)

Now, that's a lot of scientific information to absorb in one sitting. But if you understand it, you will be sure to understand this next sentence, which sums up all of the properties of organic polymers used for water clarification:

A polymer used to clarify water is an organic, cationic polyelectrolyte.

Now here's the part where it all comes together. Earlier I told you to remember that colloidal particles are negatively charged. The fact is that most all dirt particles in water are negatively charged.

OK, so we know that dirt is negatively charged, and we now know that the polymers we use to clarify water have little positive charges all along their length. Are you starting to get the picture?

We've got these huge polymer molecules, all coiled up in a bottle. When we add them to water, they uncoil, exposing little positive charges all along their length as they float through the water. We've also got these tiny, little negatively charged dirt particles floating in the water. We all know that opposites attract. So when a dirt particle gets close to a polymer, it is drawn in - just like Luke Skywalker's ship in "Star Wars" is drawn in to the Death Star by a tractor beam.

All along the length of the polymer, the same thing is happening - little bits of dirt are drawn in, and their electrical charges are neutralized a process called coagulation. As the polymer fills up with dirt, it begins to coil up again. And then a bunch of coiled polymers hook up with one another, forming large bundles or flocs.

These flocs can easily be filtered out of the water, or they may settle to the bottom. They are not nearly as large or heavy as the deposits formed by the use of alum.

Polymer-based water clarifiers are generally added at the rate of 2-2 1/2 ounces per 10,000 gallons. You must dilute the dosage with large amounts of water before you pour it in the pool, then "walk" it around the pool as you add it. If you pour it right out of the bottle into the pool, the polymer never dilutes and is attracted to the main drain, where it will be sucked into the filtration system and will neutralize and coagulate all of the dirt that is already trapped on the filter. You may as well have flushed it down the toilet.

Polymers are not pH sensitive, but they may be oxidized by high levels of chlorine. So you should check with the manufacturer to see what level of chlorine his polymer-based clarifier can tolerate.

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There are no fewer than 200 different polymers used for water clarification, and each has its own individual characteristics. Some manufacturers blend several different polymers in their clarifiers to give it a variety of effective uses - such as the ability to withstand high temperature, extreme turbulence and floc breakdown. Some polymers are better at removing soap and oil, and some are more chlorine-resistant than others.

Clearing Up The Confusion

There are a good many terms used to define water clarifiers as well as their clarifying action. The three you hear most often are agglomeration, coagulation and flocculation. These terms seem to be used interchangeably, but there are slight differences. So to set the record straight, here's what these terms really mean:

- Agglomeration -The gathering together of fine particles into a larger mass.
- Coagulation- - The neutralization of the charges of colloidal matter.
- Flocculation - The process of agglomerating coagulated particles into settleable flocs.

All of these terms are grouped together into a catch-all term called clarification.

To Sum It All Up

I hope that this has helped clear up some of the murkier points regarding water clarification.

Alum is a tried-and-true water clarifier, but it does involve a bit more work - you have to adjust the pH to use it; you have to adjust the pH and alkalinity after you have used it; and you have to vacuum up the gel-like flocs and dirt particles that settle on the pool floor. You also need to use about 4 pounds of alum to clarify a 10,000-gallon pool.

But alum does remove almost everything from the water - large and small particles; positive and negative particles; soap and oil - because it travels through the water like a blanket.

Polymer-based water clarifiers require no pH adjustment; they will not affect pH or alkalinity; and the coagulated particles formed by their use often can be filtered out without vacuuming. They also are highly concentrated, requiring only about 2 ounces to clarify a 10,000-gallon pool.

However, polymers must be diluted before you use them; and although they are very good at removing small, negatively charged particles, they are not very good at removing larger, positively charged contaminants. Their ability to remove soap and oil varies from polymer to polymer.

Alum should be used for major clean-up jobs, where the water has become extremely murky due to neglect or accident. Polymers should be used in a well-maintained pool or spa as part of your regular chemical routine, to "polish" the water by removing tiny suspended particles and to give the water that elusive snap.