Teacher Tune-up

Quick Content Refresher for Busy Professionals

About Salt Lakes

Why are some lakes salty and others not?

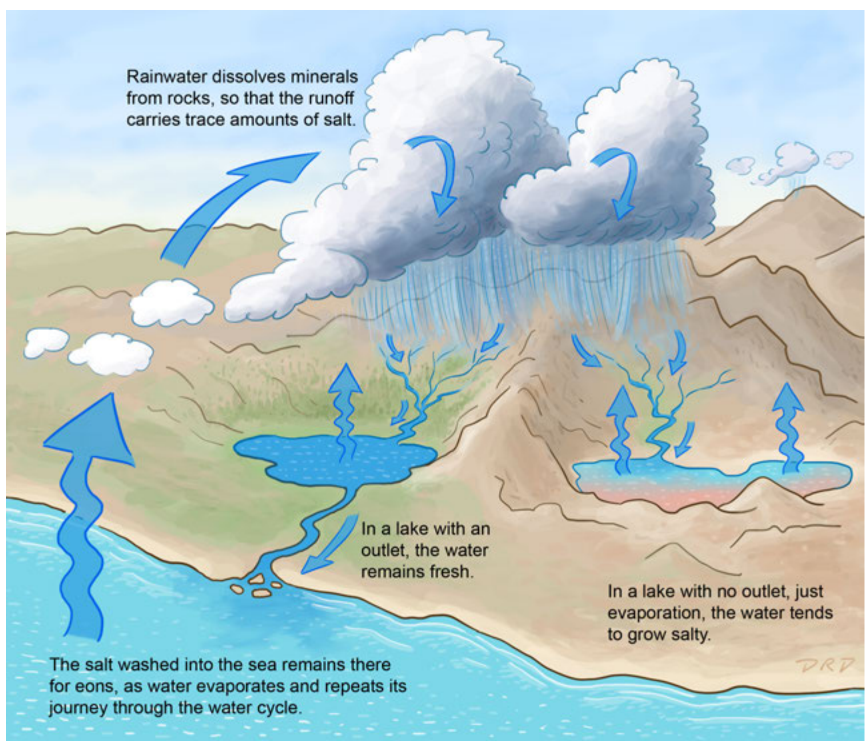
The reason some lakes are salty and others are not has to do with the water cycle, the planet-wide circulation of water from ocean to atmosphere to land and back to the ocean again. Rinse, repeat…

Salt comes from rocks. The atoms in salts (such as the sodium and chlorine atoms that make up common table salt) are locked up in the crystal structure of various kinds of rock.

Very gradually, rain erodes and dissolves rocks, so that the runoff that flows into streams and rivers carries some sodium, chlorine, and other ions. This water is still what we would call “fresh.” It has very little salt. Rivers and streams then flow either into lakes or straight to the ocean, dumping their salt into these bodies of water.

Whether a lake is fresh or salty depends on what happens next at the lake. In addition to rivers or streams that flow into them, freshwater lakes usually also have a way for water to flow out of them, like another river or stream that continues along, ultimately, to the ocean. This process of inflow and outflow keeps the salt level in freshwater lakes low.

However, when a lake has no outflow to the ocean in the form of a river or stream, the salt that flows into the lake stays there. Evaporation removes water but not salt, so the salt concentration grows until the lake becomes noticeably salty. The same process happens on a larger scale in the ocean: salt and water pour in, and as the water evaporates to form clouds and repeat the water cycle, the remaining seawater becomes very salty.



By the way, the salinity of the oceans remains fairly constant because of various “salt sinks.” To take one example, many marine organisms incorporate atoms from salts into their shells and other body parts. As these organisms die, this material settles to the ocean floor, forming oozes that are eventually transformed into sedimentary rock. This process and others counterbalance the perpetual inflow of salt from rivers, keeping ocean water about 3.5 percent salt by weight.

The salt everyone is most familiar with, table salt, is the same salt that's most abundant in the ocean: sodium chloride (NaCl). But many different salts exist. Technically, a salt is any chemical compounded of definite proportions of at least one kind of positive ion and at least one kind of negative ion, such that the charge on the ions cancel each other out. If you happen to have a periodic table of the elements on hand (don't you always?), you'll find good candidates for positive ions on the left, and for negative ions on the right. For example, good old sodium chloride is made of positively charged sodium ions (Na^+) and negatively charged chlorine ions (Cl^-).

Ions can also be polyatomic, like the carbonate ion (CO_3^+) in sodium carbonate (Na_2CO_3), a salt that is also known as soda ash. If there's a lot of soda ash in the watershed that feeds a lake with no outlet, then another special kind of lake is likely to form: a soda lake. Another name for this kind of lake is an alkaline lake, because unlike sodium chloride (NaCl), sodium carbonate (Na_2CO_3) is alkaline.

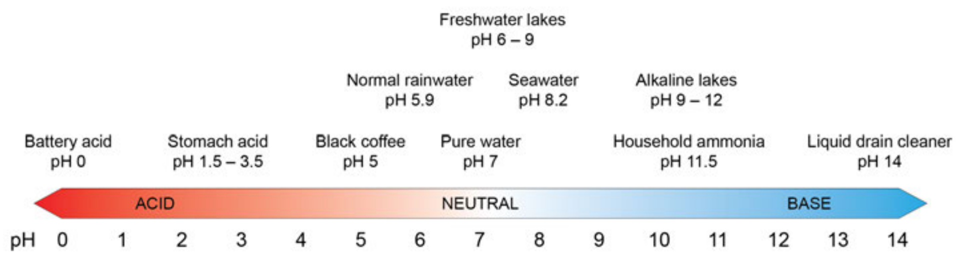
So what does all that mean if you're a chemist, or, alternatively, a flamingo? Read on.

What is an alkaline (soda) lake?

A good example of an alkaline lake is Lake Natron in Tanzania. In fact, this lake takes its name from natron, a mineral that, along with trona, is abundant in the lake. Both natron and trona contain a lot of sodium carbonate, or soda ash (Na_2CO_3). Lake Natron is salty (in the familiar sodium chloride way) as well as having lots of sodium carbonate.

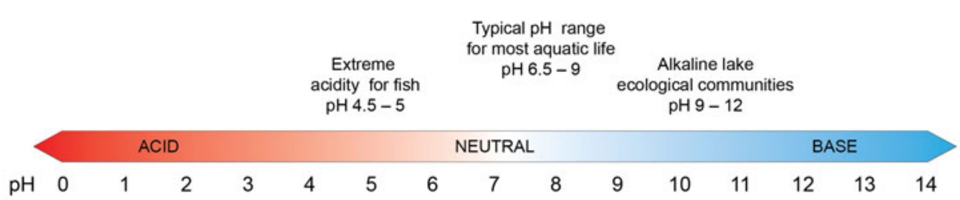
How basic, or alkaline, is Lake Natron? It has a pH of about 10.5. Other alkaline lakes range from 9 to 12. A whirlwind refresher on acids and bases may help put those numbers into perspective.

On the pH scale, numbers higher than 7 are basic; 7 is neutral; and numbers lower than 7 are acidic. Most substances range from 0 to 14 on the scale, but extremely strong acids and bases can have a pH less than 0 or greater than 14, respectively. Each whole number step on the scale denotes a tenfold change in acidity or basicity.



At a particulate level, acids donate hydrogen ions to an aqueous solution (turning more water molecules, H_2O, into hydronium ions, H_30^+). By contrast, bases accept hydrogen ions (turning more water molecules into hydroxide ions, $H0^-$). These chemically reactive hydronium and hydroxide ions are what give acids and bases their special properties, including their corrosiveness. If an acid and a base are both added to a solution, they tend to neutralize each other (leaving more unaltered H_2O than either of them alone would). In fact, this happens in some salt lakes, where positive ions like calcium (Ca+) and magnesium (Mg+) wash into the lake and partially neutralize the alkalinity of sodium carbonate (Na_2CO_3).

The pH of a lake affects what kind of life it can support. Most aquatic life needs pH levels in the 6.5 to 9 range. Below a pH of 5, the acidity starts making the water inhospitable for fish, and at 4.5, they're goners. The direct effect of excessive acidity on fish is one of the problems posed by acid rain. But there are also indirect problems. Acid rain tends to leach heavy metals from soil, and those toxic metals can end up in waterways where they can harm fish and other organisms, including people.



At the other extreme, alkaline lakes like Lake Natron are inhospitable to many forms of life, but there are organisms that are brilliantly adapted to this caustic niche. Many alkaline lakes, with their pH levels of 9-12, support permanent blooms of algae, as well as tiny crustaceans and brine shrimp. The algae blooms and other microbial life give alkaline lakes their color, ranging from bright green to orange and red. These lakes also support larger life forms that have adapted to these conditions and feed on the smaller organisms in the water.

For example, for many thousands of years, the lesser flamingos that breed at Lake Natron have benefited from their adaptation to hot, salty, high pH conditions that would be fatal to many other animals. Lake Natron, with its salt rafts and its caustic water, is the kind of real estate that your average duck is happy to leave to the flamingos.

However, these pink waterfowl could run afoul of the Tanzanian government's plans to mine soda ash from Lake Natron. The same sodium carbonate that helps make Natron an ideal flamingo habitat is also in demand for its use in glassmaking as a fluxing agent (a chemical that lowers the temperature necessary to melt the silica from which glass is made). Among the numerous ways that this industrial project could harm the flamingos, it could change the salinity and pH of the lake by diverting freshwater that used to flow into the lake, changing the conditions that the algae at the base of the food chain depend on. These changes to the lesser flamingo's last major breeding ground in East Africa could devastate the species.