Salt Water

Module 7 • i2P • H2O Tour

"Day after day, day after day,
We stuck, nor breath nor motion;
As idle as a painted ship
Upon a painted ocean.
Water, water, everywhere,
And all the boards did shrink;
Water, water, everywhere,
Nor any drop to drink."

- Samuel Taylor Coleridge, Rime of the Ancient Mariner, 1798

Not a Drop to Drink

In April, when Ray and company cross the Sahara Desert in Tunisia heading north toward the Mediterranean Sea they will have to be exceedingly careful to avoid dehydration. The Sahara is the largest hot desert in the world, and water can be very difficult to come by. It is commonly understood that the combination of excessive heat and low humidity in a desert environment puts athletes at high risk of dehydration when undertaking prolonged endurance exercise.

Dehydration is also a great danger in the wettest environment in the world: the Ocean. The principle cause of death of mariners cast adrift at sea without fresh water is dehydration. Coleridge's Rime of the Ancient Mariner eloquently captures this greatest of ironies, that one can die of thirst surrounded by water.

Salt Water

Ninety- seven percent of the water on Earth is salt water. Sea water has an average salinity of about 3.5%. What this means, in practical terms, is that every liter of sea water has about 1.2 ounces(0.15 of a cup) of salt dissolved within it. All sea water is not of equal salinity however. In places where fresh water feeds into the Ocean, salt concentration of the sea water is decreased while in areas of Ocean, such as the Red Sea in the Middle East, a place subject to high evaporation and diluted by relatively few rivers,salt concentrations can be extremely high.

Student Exercise

Take 1.2 ounces of salt and pour it into 1 liter of water. You have now created water with the average salinity of sea water.

The addition of salt to water changes the water in many fundamental ways. Salt water has a both a lower freezing point and a higher boiling point, is more dense, tastes differently than fresh water and is dangerous for humans to drink in any significant quantity.

What is salt?

Salt is a mineral made up of a variety of atoms, the two most prominent being Sodium and Chloride. These two component atoms are essential to all known living creatures although toxic to many land plants. In human beings Sodium and Chloride perform essential functions within the body that ensure health - too much or too little can be fatal. Sea salt also includes Sulfate, Magnesium, Calcium, Potassium and other minor constituents.

Salt in its mineral form is called halite, or rock salt, and is usually found in sedimentary deposits that once formed the bottom of a dried up lake or sea bed. This occurs because salt naturally dissolves in water. If a lake or a sea dries up the salt that was dissolved in it is left behind as a deposit. Many of these deposits have been mined by humans as a source of salt. When salt is dissolved in water it raises the boiling point of the water and lowers its freezing point.

Student Exercise

The great water boil off!

In your classroom take 2 pots of water of equal volume and temperature. Add 2 tablespoons of table salt to one pot. Heat the two pots at the same temperature and determine which one boils first.

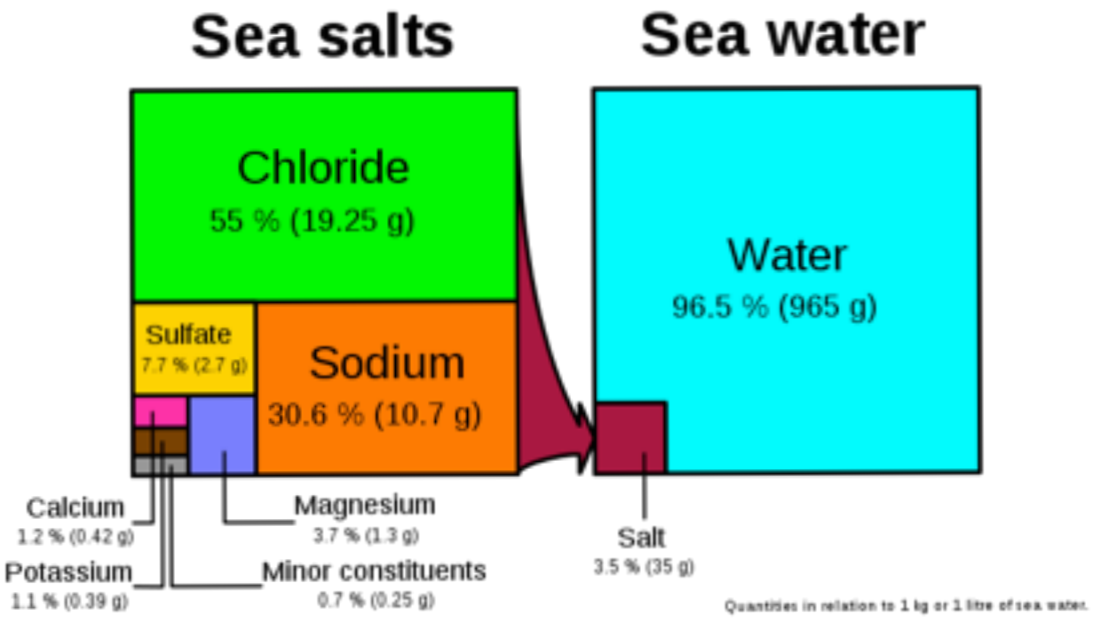

Figure 1: Chemical composition of seawater (source: Sea_salt-e_hg.svg: Hannes Grobe)

Who Put Salt in the Water?

Most lakes in the world are largely salt free. All lakes are fed by some means, be it river, stream or spring and most are in turn drained by similar means. There are some lakes, however, that aren't drained but are rather the final destination of the water that drains into them. These are called *terminal lakes.* The biggest lake in the world, the Caspian Sea (although called a sea it is by definition a lake) is a terminal lake. The Caspian Sea like all terminal lakes is salty (see: Caspian Sea)

Did You Know?

The biggest terminal lake in North America is the Great Salt Lake, located in Utah.

Figure 2: THe largest terminal lake in the world - the Caspian Sea. There are no rivers flowing out (source: NASA)

The fact that terminal lakes are salty gives us a clue to why the Ocean is salty, and regular (non-terminal lakes) are not. Salt is introduced into water as it moves through its planetary cycle (see module 4: The Water Cycle). In trace amounts it is dissolved from minerals over which surface and groundwater flows. This dissolved salt is then transported through the surface and ground water systems until it is deposited in the ocean, where it can go no further. Hence, unlike fresh water lakes which transport salt away, the salt that is deposited in the ocean collects there. Pure water is in turn removed from the ocean by evaporation, leaving the salt behind. The exact same process occurs with terminal lakes which effectively become, like the ocean, salt collecting vessels (see: salty oceans). Unlike terminal lakes the ocean has an added source of salt introduced from below the Earth's crust through fissures in the ocean floor called sub-oceanic vents.

Despite the steady introduction of salt into oceans the salinity of the oceans is in a steady state. This means that the average salt level in the oceans is neither rising or falling. Rivers carry an estimated 4 billion tons of salt to the ocean each year, but approximately the

Did You Know?

The ocean:

- covers 71 percent of the Earth's surface;
- contains 97 percent of the planet's water, and;
- supports the life of nearly 50 percent of all species on Earth

Figure 3: Man demonstrating the bouancy of the high salinity of the Dead Sea (source: Wikimedia Commons - en:User:Pcb21)

same amount of salt is deposited annually onto the ocean floor, explaining why the ocean is not becoming saltier (see: ocean salt). This is not the case for many terminal lakes which are shrinking and becoming more salty with time. One of the highest salt concentrations in the world is found in the Dead Sea, where the very high water density enables swimmers to float about with ease. The Dead Sea gets its name from it's lifeless waters and barren surrounding terrain. This occurs because at the high levels of salinity found in the Dead Sea very little life can survive.

Drinking Salt Water

As evidenced by the fact that the majority of the worlds creatures live in the ocean, there are many animals that have adapted to a saline environment. Although human beings can safely swim in the ocean, we cannot drink significant amounts of salt water without becoming ill and ultimately dying if we have no source of fresh water. This occurs because the human kidney is not adapted to manage the excess salt found in ocean water in a manner that preserves health.

The balance of salt in our bodies is essential to human survival. Both an excess and a reduction of salt in our blood can lead to marked illness and sudden death. When human beings drink sea water the high salt content causes our kidneys to work to eliminate the salt from our bodies. In order to do so the kidneys must excrete large volumes of water to carry out the salt, an amount,in fact, greater than the volume ingested with the sea water. In other words drinking sea water will cause your body to excrete more water than it takes in, leading to dehydration and ultimately death (see: drinking salt water).

Is Salt water Dangerous for All to Drink?

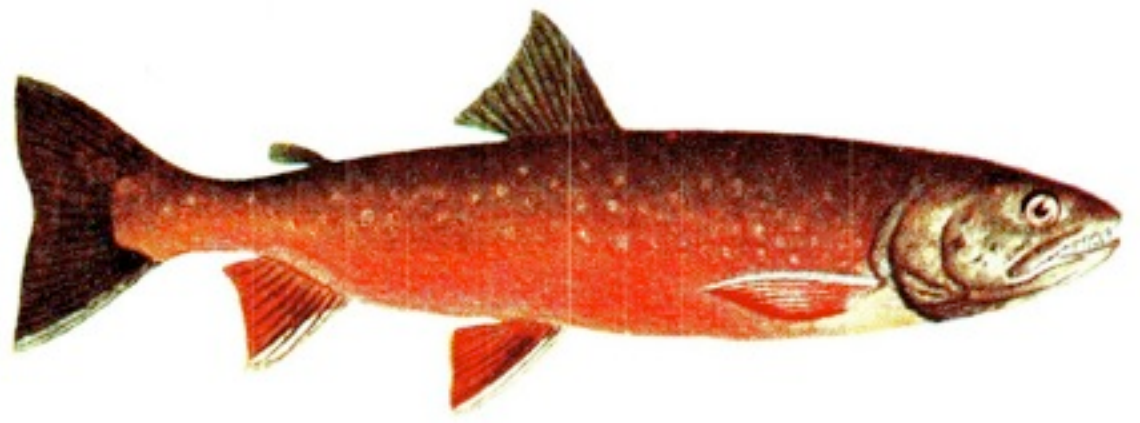

Figure 4: Arctic Char - an anadromous fish (source: Wikimedia Commons)

The irony of our inability to live off sea water is that all life on the planet, including human life is thought to have originated, billions of years ago, in the oceans. Although we lost our ability to live in the sea, many creatures have made adaptations that allow them to manage the high saline environment of the ocean. Marine fish, for instance, have developed an enzyme that selectively pumps salt out of their gills. Conversely fresh water fish accomplish the opposite, secreting unusually high volumes of water in their urine that allows them to maintain acceptable salt levels in their bodies (see: salt water adaptation). Remarkably there are some species of fish such as the Arctic Char that are able to safely live in both salt and freshwater. Fish that have the ability to live in both salt and fresh water are called anadromous (see: arctic char).

No Sweat

Have you every exercised so strenuously that the sweat from your brow has dripped into your mouth? How does it taste? Indeed another reservoir of salt water on the earth, albeit a miniscule one, is the human body.

When human beings sweat they lose salt in the process. If you have ever let your sweaty tee-shirt dry out after exercising you may see salt patterns on it. The human body is adapted to carefully manage the salt, and this balance is influenced by sweating. Sweating is a mechanism the body uses to dissipate heat during exercise so that it doesn't overheat. Heat is conducted by water about twenty-four times quicker than by air (for a complete list of the thermal conductivity of substances see: thermal conductivity). That is why you'll freeze to

Student Exercise

Demonstrate the greater capacity of water to conduct heat away than air (thermal conductivity), by boiling water in a paper cup. See the elegant experiment:

Boil water in a paper cup

death far quicker (theoretically 24 times quicker!) by falling into water at zero degrees than by standing outside in zero degree air temperatures. The body employs the thermal conductivity of water to most effectively conduct heat away from itself, preventing hyperthermia (overheating), but in so doing, loosing salt. It is based on this loss that sport drinks contain salt.

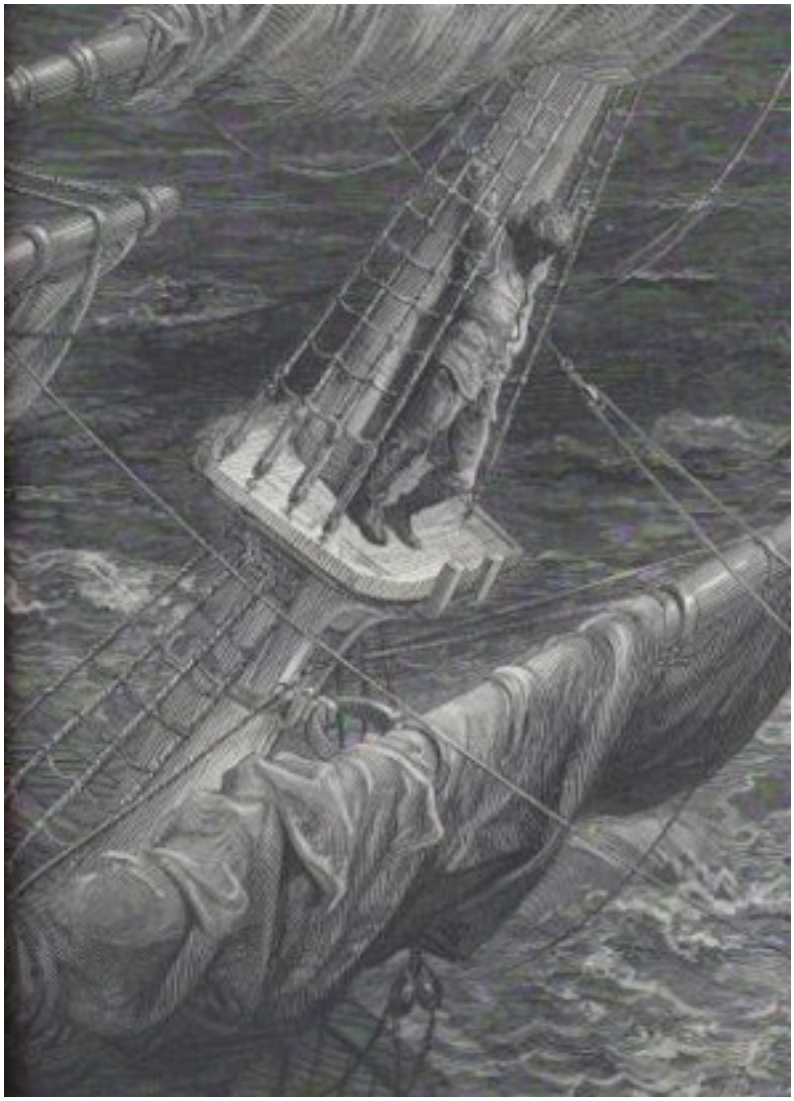

Figure 5: The Rime of the Ancient Mariner, by Gustav Dore (source: Wikimedia Commons)

The Human Saltwater Reservoir

So whether passing over Lake Baikal, or across the Tunisian desert, Ray and the team will be sweating (as well as urinating!), and will thereby be relocating saltwater from their bodies to the local environment. This lost salt and water will be replaced in the food and drink they ingest.

In winter, on Lake Baikal, the salt water they produce will freeze to the surface of the lake awaiting the coming of spring. If the water is not sublimated water vapor, it will melt with the arrival of warm weather. The traces of salt will be dissolved in the lake with the spring melt and, will ultimately flow into the rivers that drain the lake, the Angara and the Yenisei on their journey north to the Arctic Ocean. And so the salt from the sweat of the i2P team will be introduced to the sea.

The saltwater produced by the i2P team in Tunisia will fall to the desert floor where the water will be absorbed into the earth or, more likely, evaporated by the relentless desert

sun. The traces of salt left behind in the sand of Tunisia will likely remain there for a long time.