CHLORIDE - CHLORINE . . . WHAT'S THE DIFFERENCE?

by Alexander G. Schauss, Ph.D.

Chloride is often confused with chlorine. What is the difference?

Chloride (Cl)

Chloride (Cl) is a naturally occurring element found in abundance in nature. For example, the average concentration of chloride in sea water is 18.98%. In fact, it is the most abundant negative ion (anion) in the ocean, constituting nearly 90% of the anions found in sea water. Chlorine, by comparison, is found mainly in the earth's crust, where it constitutes approximately 0.045% of the crust.

Sodium (Na), another naturally occurring element found in sea water, is positively charged (cation) and the most abundant positive ion (cation) in sea water. Because negative and positive ions can attract to one another, sodium and chloride combine to form a nutritionally important compound called sodium chloride (NaCl). Sodium chloride is often called "salt" although other anions and cations that combine can form salts such as magnesium sulfate, potassium chloride, etc. Many "salts" we consume are essential to our health. In fact, without sodium chloride we would die. Chloride deficiency is fortunately very rare, but can cause death if untreated. By comparison, the chlorine compound added to sterilize public drinking water supplies can combine with water pollutants to form highly toxic chemicals, which complicates its benefits to public health. Table 1 shows the levels of the major anions and cations found in sea water.

The salinity of sea water varies, between 33 to 37 percent. However, some brackish waters may have a salinity level below 25, while some hypersaline waters may be greater than 40. Yet the ratio of the dissolved anions and cations in sea water remain fairly constant regardless of the total saline content. In some marine environments, such as inland seas, the ionic ratios of the dissolved anions and cations may be significantly different.

Enclosed seas or inland seas, such as the Great Salt Lake in Utah, contain very different ionic

Table 1

	Ion	**Percent by Weight**
Negative ions (anions)	Chloride (Cl^-)	18.980
	Sulphate (SO_4^{2-})	2.649
	Bicarbonate (HCO^{3-})	0.140
	Bromide (Br^-)	0.065
	Borate (H_2BO^{3-})	0.026
	Fluoride (F^-)	0.001
Positive ions (cations)	Sodium (Na^+)	10.556
	Magnesium (Mg^{2+})	1.272
	Calcium (Ca^{2+})	0.400
	Potassium (K^+)	0.380
	Strontium (Sr^{2+})	0.013
	Overall Total Salinity	34.482 %

ratios. This occurs because of the addition of substantial amounts of certain elements provided by the chemical weathering of rocks around the inland sea. Chemical weathering occurs when slightly acidic rainwater (around a pH of 5.7) falls on land. The acid rain causes reactions to occur between the rain and the minerals in the rocks and soil. The end result can be exceptionally large increases in elements and mineral compounds that are not normally found in sea water becoming slowly deposited in the inland sea. If this process continues for thousands of years, the inland sea eventually becomes a source of many minerals. This is exactly why the state of Utah is the richest commercial mineral deposit in the United States. Inland seas that have expanded and shrunk over more than 10 million years have deposited untold riches in minerals which are commercially mined and harvested today.

The average chloride content of the rocks in the continental crust is around 0.01%. For this reason it is unlikely that river or creek water pouring into the ocean or an inland sea could contribute much chloride through weathering. It has been determined that virtually all of the chloride in river water is a result of sea salt that has either been recycled through geologic forces or oceanic aerosols. (The dissolved constituents found in river water that are a result of rock weathering are predominantly calcium and bicarbonate ions.)

So where might abundant levels of chloride come from that are found in such inland seas as the Great Salt Lake which are hundreds of miles from oceanic aerosols? Especially when rainwater is 5,000 times more dilute and river water is about 300 times more dilute, respectively, than sea water. The answer is volcanism. Hydrogen chloride is an important constituent of gases that erupt out of volcanoes. During the first 2,500 million years of Earth's existence, large quantities of hydrogen chloride were emitted.

Abundant levels of chloride are found in the ocean. The hydrogen chloride was dissolved in the ocean many millions of years ago. In fact, virtually all of the chloride in the ocean today comes from this primeval source. Even today, hydrothermal activity in the ocean basins, especially at the sites of rifts in the ocean floor involved in sea floor spreading continue to contribute a small amount of chloride to the world's oceans.

These geologic forces are the primary sources of chloride found in the ocean. They contribute to the chloride levels found in inland seas such as Utah's Great Salt Lake and in other geographic locations around the world, such as the Dead Sea in the Middle East.

As is seen in Table 1 the chloride ion is the most abundant ion in sea water. Because of the equilibrium constants for interactions between major cations and chloride, chloride is effectively a free ion with respect to other major cations in sea water. This is why unbound "ionic magnesium-rich" dietary supplement solutions derived from Utah's Great Salt Lake can exist in their ionic state. The magnesium in a dietary supplement from such sources does not bind with chloride to form a salt such as magnesium chloride. This is important to know since some mistakenly believe that because there is an anion and a cation ion in the same solution, the two will automatically combine. If things were so simple in chemistry, we would not need to study chemistry for so many years to understand the much more complicated dynamics of exchange that can or can not occur on varying conditions to form compounds chemists study.

Importance to Human Health and Functioning

The human body is approximately 0.15 percent chlorine (around 95 grams or 2,680 mmoles in an average male and around 70 grams or 2,000 mmoles in an average female), which is almost exclusively in the form of chloride (National Academy of Sciences, RDA 10th Edition). According to the U.S. National Academy of Sciences, chloride is essential in maintaining fluid and electrolyte balance, and is a necessary component of gastric juice. (NAS, page 257) The highest concentration of chloride is found in secretions of the gastrointestinal tract, particularly as stomach hydrochloric acid, and in cerebrospinal fluid. High concentrations are also found in extracellular fluid where it is the principle inorganic anion.

Many years ago a scientist pointed out that the extracellular compartments in the environment surrounding our cells contain constituents and concentrations of elements that are almost identical with the earliest Precambrian seas, during the formative period of the earth's history. During this period hundreds of millions of years ago the earliest primordial unicellular organisms survived. These earliest life forms developed organs (called organelles) and cells in this primordial bath. Some of these organs continued the evolutionary pathway until they became known as the kidneys. The kidneys of a diverse range of organisms on this planet all came from this aquatic environment. Today all biological life forms on this planet, having in common the task of guarding and regulating the external and internal components of our cells, require the kidneys to perform this task. The kidneys perform this function by regulating sodium, chloride and potassium concentrations in the body. The concentrations of these three elements are regulated within extremely narrow limits. The ability to keep these elements in relative homeostasis throughout our lives is what permits so many other essential biochemical events to take place within our body's cells. This allows our cells to thrive and perform a multitude of tasks. Without chloride, therefore, our cells could not survive, nor could we.

Chloride in our diet comes primarily from daily ingestion of sodium chloride (common table salt). In general, loss of chloride is associated with a parallel loss of sodium. If we reduce our intake of sodium chloride, a drop in urinary excretion of chloride will immediately follow, to conserve chloride levels. We also experience loss of chloride in association with sweating and/or diarrhea. In cases of vomiting, the loss of chloride may well exceed that of sodium. That is why both sodium and chloride status needs to be evaluated in patients suffering from an eating disorder called bulimia nervosa.

In the United States, water contributes approximately 42 milligrams a day of chloride to the diet. By comparison, foods consumed by Americans provide roughly 6,000 milligrams of chloride a day, most of which comes from sodium chloride (table salt) added to food.

The only known cause of dietary-related chloride toxicity is due to water-deficiency dehydration. However, continuous intakes of high levels of chloride from sodium chloride (table salt) can result in elevated high blood pressure in sensitive individuals.

In summary, chloride is absolutely essential to the survival of cells in the human body and to human health in general. This is not the case with chlorine, which at certain levels can lead to serious health problems.

Chlorine

Unlike chloride, which is abundant in sea water, chlorine is abundant in the igneous rock that constitutes 95% of the earth's crust, and constitutes 0.045% of the earth's crust. It combines with metals, nonmetals, and organic materials to form hundreds of compounds. It is a chemical element (Cl) of atomic number 17 that exists as a greenish-yellow gas at ordinary room temperatures and pressures. Only fluorine, another element, is more reactive, among the halogen elements, and hence is found free in nature only at the elevated temperatures found in volcanic gases.

Commercially, chlorine is created by large scale operations that use electrolysis from fused chlorides. This makes the end product form all kinds of chemicals, some of which are useful, while others are very dangerous.

Chlorine itself is a common compound that has potent disinfectant qualities that can rapidly inactivate bacteria, viruses, and protozoan cysts. It is the most commonly used chemical to disinfect waste water from sewage treatment plants, municipal water supplies and biofouling at power plants.

In the last twenty years, serious concerns have developed in regards to the use of chlorine as a biocide in public drinking water. These concerns can be divided into four groups:

1) the reactions of chlorine with water;
2) the formation of chlorine-produced oxidants such as chloramines;
3) transformation and decomposition reactions of chlorine and chlorine-produced oxidants; and,
4) the interaction of chlorine and its reaction and transformation products with other life forms.

The disinfection of water with chlorine is the major source of synthetic organic chemicals found in public drinking water supplies. Chlorine reacts with naturally occurring organic compounds in water treatment plants to produce halogenated byproducts. These can have adverse long-term health effects.

Chlorination began to be used to control microbiological contamination in drinking water in the United States in 1908. Many years later it became evident that chlorination could produce carcinogenic by-products such as chloroform and trihalomethanes (THMs). Today it is known that chlorination can produce nearly two dozen toxic by-products. Chlorine residuals have even been found to interact with a diet marginal in calcium and to produce signs of arteriosclerosis and myocardial hypertrophy in animals. Experts on chlorination have even conceded that "the benefits of chlorine to control infectious disease may be, in part, offset by increased cancer risk in continuously exposed populations." Additional sources of drinking water supplies that may be contaminated by chlorine are agricultural and municipal runoffs, waste dumps, and industrial pollution. Drinking water chlorination and cancer occurrence in a number of different populations have been shown to elevate rates of colon, bladder, and rectal cancer mortality. Chlorine drinking water treatment significantly increases mutagenic activity. Scientists have even reported that

> "...we must consider the potential reproductive effects of life-time exposure to chlorine...The populations potentially at risk include not only male and female populations of childbearing age, but also those perinatally exposed. The effects on the perinatal population may be immediate, resulting in birth defects or increased perinatal mortality or morbidity."

Infants consume approximately three times more liquid per pound of body weight than do adults. This increased fluid intake relative to body weight would maximally expose the perinatal and infant group to water than has been chlorinated. There is also evidence that chlorination, particularly with chlorine dioxide, may adversely affect thyroid function and prenatal brain development.

In summary, chlorine is a naturally occurring element, but because of its reactivity to other elements, it can form many compounds that are potentially at risk to human health.

MRI

Mineral Resources International
P.O. Box 190 • Roy, UT 84067 • USA
www.mineralresourcesint.com

international:	(801) 731-7040
toll free:	(800) 731-7866
fax:	(801) 731-7985