
THE DEADLY FACTS ABOUT
WATER!
FACT!
WATER CAN BE CHEMICALLY SYNTHESIZED BY BURNING ROCKET FUEL!!!
FACT!
OVER CONSUMPTION CAN CAUSE EXCESSIVE SWEATING, URINATION, AND EVEN DEATH!!!
FACT!
100%
OF ALL SERIAL KILLERS, RAPIST AND DRUG DEALERS HAVE ADMITTED TO DRINKING WATER!!!
FACT!
WATER ONE OF THE PRIMARY INGRIDIENTS IN HERBICIDES AND PESTICIDES!!!
FACT!
WATER IS THE LEADING CAUSE OF DROWNING!!!
FACT!
100 PERCENT OF ALL PEOPLE EXPOSED TO WATER WILL DIE!

Marathon runner narrowly avoids death after drinking too much water

- A seasoned marathon runner had no recollection of finishing her race or the fact that she suffered a seizure once she was back home.
- Johanna Pakenham drank approximately 20 small bottles of water to cope with the heat during this year's London Marathon.
- Before Pakenham was diagnosed with **hyponatremia**, a condition which is also dubbed "water intoxication", her partner needed to perform CPR while waiting for an ambulance.
- **Hyponatremia**, or water intoxication, happens when you drink too much water and the sodium levels in your body plummet to an unusual low.
- *Sodium is an essential electrolyte* in your body, which helps nerves and muscles function optimally, along with keeping blood pressure stable.
- Consuming too much water causes cells in the body to swell. It also causes the brain to swell – and the pressure of the brain against the skull could result in seizures. It could also result in heart failure, respiratory distress and renal distress.

Outline

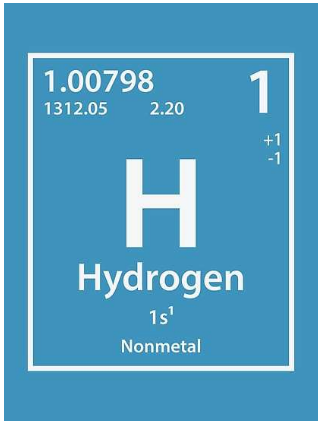
- Definitions
- Water – The Universal Solvent
- Salt – In solution with water
- Chemistry 101
- pH
- Acid Base Systems
- Hard Water
- Corrosion
- Compliance

What is H_2O

Physical Properties of H_2O or as it's commonly called "water"

- **Water is a transparent, tasteless, odorless, and nearly colorless chemical substance**, which is the main constituent of Earth's streams, lakes, and oceans, and the fluids of most living organisms. It is vital for all known forms of life, even though it provides no calories or organic nutrients. Its chemical formula is H2O, meaning that each of its molecules contains one oxygen and two hydrogen atoms, connected by covalent bonds. **Water** is the name of the **liquid state** of H2O at standard ambient temperature and pressure. It forms precipitation in the form of rain and aerosols in the form of fog. Clouds are formed from suspended droplets of water and **ice**, its **solid state**. When finely divided, crystalline ice may precipitate in the form of snow. The **gaseous state** of water is **steam or water vapor**. Water moves continually through the water cycle of evaporation, transpiration (evapotranspiration), condensation, precipitation, and runoff, usually reaching the sea.

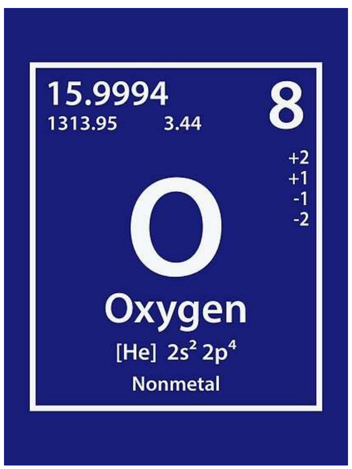
- Water is a liquid between 0 and $100^{o}C$
- The maximum density of water in its liquid form occurs at $4^{o}C$ ($39.3^{o}F$).
- Boiling point at $100^{o}C$ ($212^{o}F$)
- Freezing point $0^{o}C$($32^{o}F$)
- Absorbs light in the blue spectrum hence the blue hue of water.
- A polar molecule, the oxygen atom carries a slight negative charge whereas the hydrogen atoms are positive.
- Water is a polar solvent



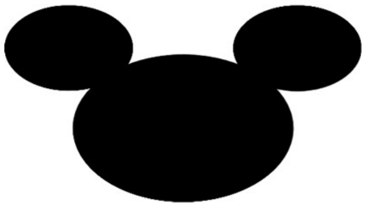
What's in a name? From the Greek words **hydro** and **genes**, which together mean "water forming."

Composed of a single proton and a single electron, hydrogen is the simplest and most abundant element in the universe. It is estimated that 90% of the visible universe is composed of hydrogen.

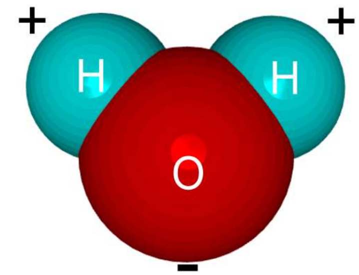
Hydrogen combines with other elements to form numerous compounds. Some of the common ones are: water (H_2O), ammonia (NH_3), methane (CH_4), table sugar ($C_{12}H_{22}O_{11}$), hydrogen peroxide (H_2O_2) and hydrochloric acid (HCl).



What's in a name? From the Greek words **oxys** and **genes**, which together mean "acid forming."
Oxygen is the third most abundant element in the universe and makes up nearly 21% of the earth's atmosphere. Oxygen accounts for nearly half of the mass of the earth's crust, two thirds of the mass of the human body and nine tenths of the mass of water.
Oxygen is a highly reactive element and is capable of combining with most other elements. It is required by most living organisms and for most forms of combustion.
Oxygen can also be combined with acetylene (C_2H_2) to produce an extremely hot flame used for welding. Liquid oxygen, when combined with liquid hydrogen, makes an excellent rocket fuel.
Ozone (O_3) forms a thin, protective layer around the earth that shields the surface from the sun's ultraviolet radiation. Oxygen is also a component of hundreds of thousands of organic compounds.

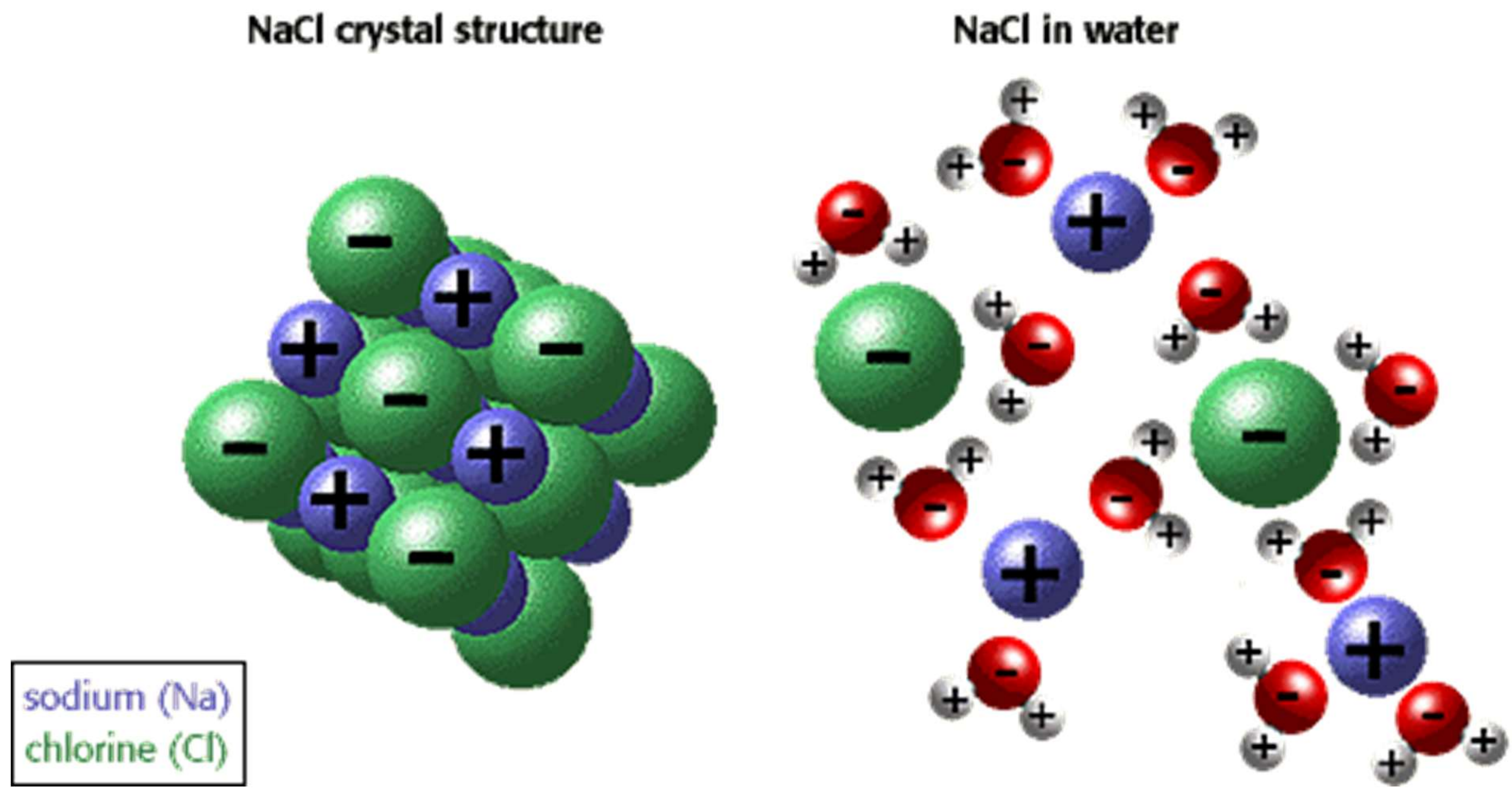


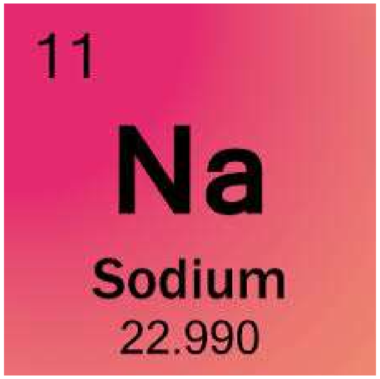
Water – The Universal Solvent



- Water is capable of dissolving a variety of different substances, which is why it is such a good solvent. And, water is called the "universal solvent" because it dissolves more substances than any other liquid. This is important to every living thing on earth. It means that wherever water goes, either through the ground or through our bodies, it takes along *valuable chemicals, minerals, and nutrients*.
- It is water's chemical composition and physical attributes that make it such an excellent solvent. Water molecules have a polar arrangement of the oxygen and hydrogen atoms—one side (hydrogen) has a positive electrical charge and the other side (oxygen) had a negative charge. This allows the water molecule to become attracted to many other different types of molecules. Water can become so heavily attracted to a different molecule, like salt (NaCl), that it can disrupt the attractive forces that hold the sodium and chloride in the salt molecule together and, thus, dissolve it.

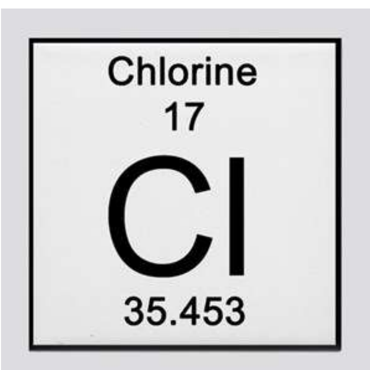
NaCl – Salt in solution with water



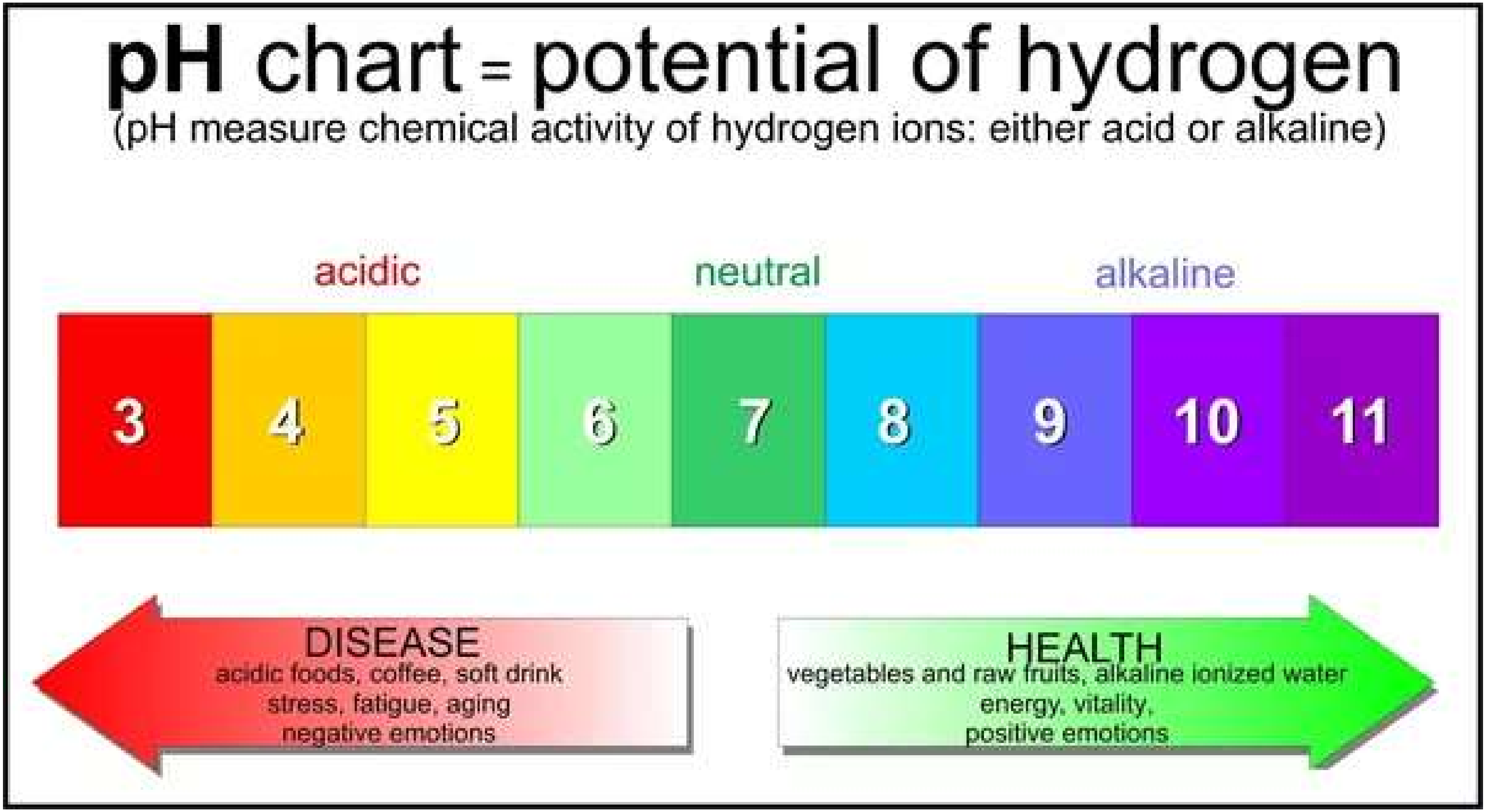


What's in a name? From the English word **soda** and from the Medieval Latin word **sodanum**, which means "headache remedy." Sodium's chemical symbol comes from the Latin word for sodium carbonate, **natrium**.
Say what? Sodium is pronounced as **SO-dee-em**.

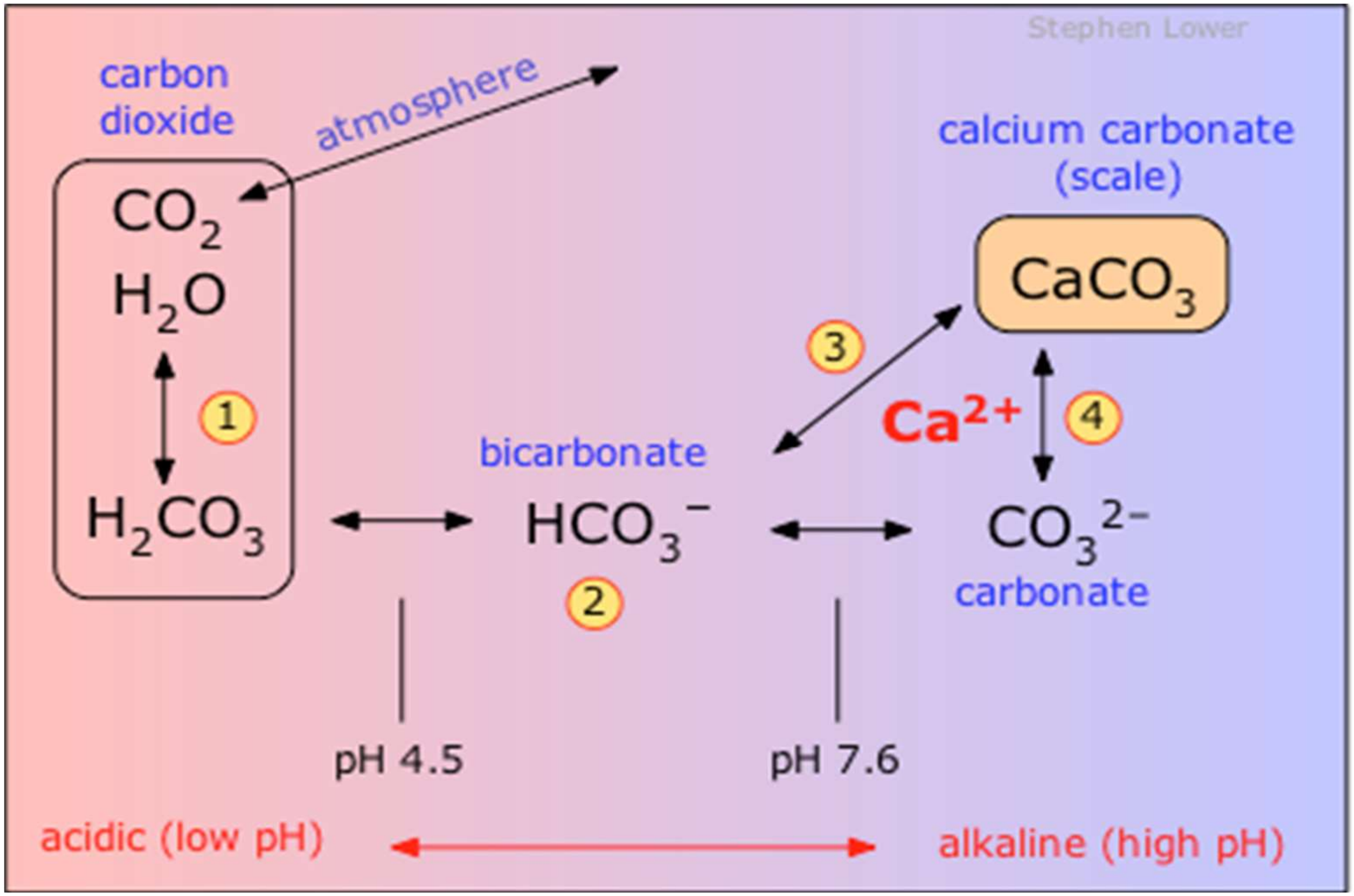
Although sodium is the sixth most abundant element on earth and comprises about 2.6% of the earth's crust, it is a very reactive element and is never found free in nature. Pure sodium was first isolated by Sir Humphry Davy in 1807 through the electrolysis of caustic soda (NaOH). Since sodium can ignite on contact with water, it must be stored in a moisture free environment.
Sodium also forms many useful compounds. Some of the most common are: table salt (NaCl), soda ash (Na_2CO_3), baking soda ($NaHCO_3$), caustic soda (NaOH),



What's in a name? Chlorine is derived from "khloros," from Greek word for greenish-yellow, and in 1810, the name was updated to "chloric gas," or "chlorine."
Probably the most known form of a chlorine compound is **sodium chloride**, otherwise known as **table salt**. It is used to sterilize drinking water and to disinfect swimming pools, and it is used in the manufacturing of a number of commonly used products, such as paper, textiles, medicines, paints and plastic, particularly PVC. But chlorine also has a dark side: **Its natural form is a gas**, it is harmful to human health. Chlorine is a respiratory irritant, and inhaling it may cause pulmonary edema — an excessive buildup of fluid in the lungs that can lead to breathing difficulties.


pH chart = potential of hydrogen
(pH measure chemical activity of hydrogen ions: either acid or alkaline)
acidic
neutral
alkaline
3
4
5
6
7
8
9
10
11
DISEASE
acidic foods, coffee, soft drink
stress, fatigue, aging
negative emotions
HEALTH
vegetables and raw fruits, alkaline ionized water
energy, vitality,
positive emotions

The Origin of Water Hardness



Hard Water

- When water is referred to as 'hard' this simply means, that it contains more minerals than ordinary water. These are especially the minerals calcium and magnesium. The degree of hardness of the water increases, when more calcium and magnesium dissolves.
- Magnesium and calcium are positively charged ions. Because of their presence, other positively charged ions will dissolve less easily in hard water than in water that does not contain calcium and magnesium.
- Hard water problems are most likely to occur when water is heated.

Water Softening

- When water contains a significant amount of calcium and magnesium, it is called hard water. Hard water is known to clog pipes and to complicate soap and detergent dissolving in water.
- Water softening is a technique that serves the removal of the ions that cause the water to be hard, in most cases calcium and magnesium ions. Iron ions may also be removed during softening.
- The best way to soften water is to use a water softener unit and connect it directly to the water supply.

What is a water softener?

- A water softener is a unit that is used to soften water, by removing the minerals that cause the water to be hard.
- Softened water still contains all the natural minerals that we need. It is only deprived off its calcium and magnesium contents, and some sodium is added during the softening process. That is why in most cases, softened water is perfectly safe to drink. It is advisable that softened water contains only up to 300mg/L of sodium.

Why is water softening applied?

- Hard water causes a higher risk of lime scale deposits in household water systems. Due to this lime scale build-up, pipes are blocked and the efficiency of hot boilers and tanks is reduced. This increases the cost of domestic water heating by about fifteen to twenty percent.

What does a water softener do?

- Water softeners are specific ion exchangers that are designed to remove ions, which are positively charged.
- Softeners mainly remove calcium (Ca2+) and magnesium (Mg2+) ions. Calcium and magnesium are often referred to as 'hardness minerals'.
- A water softener collects hardness minerals within its conditioning tank and from time to time flushes them away to drain.
- Ion exchangers are often used for water softening. When an ion exchanger is applied for water softening, it will replace the calcium and magnesium ions in the water with other ions, for instance sodium or potassium. The exchanger ions are added to the ion exchanger reservoir as sodium and potassium salts (NaCl and KCl).

Corrosion reactions

$Cl_2 + H_2O \Leftrightarrow HOCl + HCl$

Chlorine and **Water** ***Hypochlorous Acid*** and ***Hydrochloric Acid***

$CaSO_4 + H_2O \Leftrightarrow H_2SO4 + Ca(0H)_2$

Calcium sulfate and Water ***Sulfuric Acid*** and **Calcium Hydroxide**

Corrosion in hot water systems

- Galvanic corrosion
- Caustic corrosion
- Acidic corrosion
- Hydrogen embrittlement
- Oxygen attack
- Carbon dioxide attack

Galvanic Corrosion

- Galvanic corrosion occurs when a metal or alloy is electrically coupled to a different metal alloy. The most common type of galvanic corrosion in a boiler system is caused by the contact of dissimilar metals, such as iron and copper.

Caustic Corrosion

- Concentration of caustic (NaOH) can occur as a result of steam blanketing (which allow salts to concentrate on boiler metal surface) or by localized boiling beneath porous deposits on tube surface. Caustic corrosion occurs when caustic is concentrated and dissolves the protective magnetite (Fe_3O_4) layer, causing a loss of base metal and eventual failure.

Acidic corrosion

- Low make up feed water pH can cause serious acid attack on metal surfaces in the pre-boiler and boiler system. Feed water can also become acidic from contamination of the system (process contamination of condensate or cooling water contamination from condensers).
- Acidic corrosion can also be caused by chemical cleaning operations (overheating of the cleaning solution, excessive exposure of metal to cleaning agent, high cleaning agent concentration).

- In the boiler and feed water system, acidic attack can take the form of general thinning, or it can be localized at areas of high stress.

Boiler feed water

- Proper treatment of boiler feed water is an important part of operating and maintaining a boiler system. As steam is produced, dissolved solids become concentrated and form deposits inside the boiler. This leads to poor heat transfer and reduces the efficiency of the boiler.
- Scale deposits in boiler, inhibits heat transfer, and thermal efficiency. In severe cases can lead to boiler tube burn thru, and failure.

Oxygen attack

- Without proper mechanical and chemical deaeration, oxygen in the feed water enters the boiler. Much is flashed off with the steam; the remainder can attack boiler metal. Oxygen in water produces pitting that is very severe because of its localized nature. Water containing ammonia, particularly in the presence of oxygen, readily attacks copper and copper bearing alloys. The resulting corrosion leads to deposits on boiler heat transfer surfaces and reduces efficiency and reliability.

- Oxygen is highly corrosive when present in hot water. Even small concentrations can cause serious problems: iron oxide generated by the corrosion can produce iron deposits in the boiler. Oxygen corrosion may be highly localized or may cover an extensive area. Oxygen attack is an electrochemical process

Carbon dioxide attack

- Carbon dioxide exists in aqueous solutions as free carbon dioxide and the combine forms of carbonate and bicarbonate ions. Corrosion is the principal effect of dissolved carbon dioxide. The gas will dissolve in water, producing corrosive carbonic acid.
- Carbon dioxide corrosion is frequently encountered in condensate systems and less commonly in water distribution systems.

Drinking water treatment systems face a dilemma:

Two regulations from the U.S. Environmental Protection Agency (EPA), the **Lead and Copper Rule** and the **Surface Water Treatment Rule**, seem to work against each other, even though each rule is meant to benefit the public.

The **Lead and Copper Rule (LCR),** which EPA implemented in 1991, mandated water treatment systems sample their treated water for lead and copper. Internal pipe corrosion can lead to both aesthetic problems (staining fixtures and laundry) and consumer health issues.

The **Surface Water Treatment Rule(SWTR)**, which EPA will implemented in the fall of 1989, requires most water systems to filter and disinfect. Operators must monitor systems for microbiological contamination. These systems must then remove or inactivate microorganisms to prevent them from reaching consumers. Because many smaller water systems rely on groundwater, this rule will affect them the most.

The most common disinfection method is to add chlorine, a corrosive agent, to water. Concerns arise because disinfecting to comply with the SWTR may push water systems out of compliance with the Lead and Copper Rule. Further, adding chlorine to the finished water may make other metals in a system more likely to corrode.

A team of researchers in Wisconsin sponsored by the Midwest Technical Assistance Center (MTAC) studied chlorine's effect on corrosion in drinking water systems. Their research found that introducing free chlorine for disinfection increased corrosion. Adding free chlorine appears to affect iron the most. Chlorine also appears to have an effect on copper and lead, but it may or may not increase corrosion with these metals.

Simultaneous Compliance with Regulations

- National Primary Drinking Water Regulations
- Clean Water Act
- Safe Drinking Water Act
- Total Coliform Rule
- Lead and Copper Rule
- Stages 1 & 2 Disinfection Byproduct Rule (DBPR)...Stage 3 coming
- Surface Water Treatment Rule
- Interim Enhanced Surface Water Treatment Rule (IESWTR)
- Long Term 1 & 2 Enhanced Surface Water Treatment Rule (ESWTR)
- Cross Connection Control

THE EFFECT OF CHLORINE ON CORROSION IN DRINKING WATER SYSTEMS

FINAL REPORT

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