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JOHN'S CORNER:

MINERALS - The Elements and What They Do (Part 10)

by John Ferguson

17) Chlorine (Cl) - Chlorine is found in igneous rocks at 130 ppm, shale at 180 ppm, limestone at 150 ppm, sandstone at 10 ppm, fresh water at 7 ppm, sea water at 19,000 ppm, marine plants at 4,700 ppm, land plants at 2,000 ppm and land animals at 2,800 ppm. Most soils only have around 100 ppm of chlorine.

If you notice that chlorine is found in the same column on the periodic table as fluorine (F) and bromine (B), hence it has very similar chemical properties and is highly reactive.

Chlorine is an element where small amounts are essential to health from microbes, plants, animals, and humans and too much is toxic.

Chlorine exists as a molecule in the form of two chlorines atom that are coupled (Cl_2) which is extremely reactive and dangerous. It is a dense greenish-yellow gas with a sharp pungent smell. Chlorine is extremely reactive and will form compounds with all elements except the noble gases. Chloride is a chlorine atom that has a negative electrical charge (Cl^-) which is stable and relatively safe. Chlorine is commonly found in nature as Halite (rock salt) which is sodium chloride (NaCl) and is the main source of chlorine for all living organisms.

Chlorine is essential for all living species, used in electrochemical and catalytic functions, activates numerous enzyme functions, and raw material our digestive system uses to make stomach acid which is hydrochloric acid (HCl). It is required for vitamin B-12 absorption.

Chlorinated lime or calcium hypochlorite $Ca(ClO)_2$ was one of the first disinfectants used by doctors to wash their hands between patients, reducing mortalities by 90% after it started being used. Chlorine is the most common disinfectant used in public water systems.

Chlorine is required to make plastics like (PVC) poly vinyl chloride $(CH_2CHCl)_n$ which is long chains of carbon atoms with a chlorine atom attached to every other one. Chlorine is used in the manufacture of hundreds of products.

Chlorine gas (Cl_2) was used as a chemical weapon in WW-I due to its extreme toxicity, as it effectively attacks all living cells (both good and bad). It starts attacking eyes and lungs in concentrations as low as 3 ppm. Studies have found that our white blood cells use chlorine gas to fight infections.
When we drink chlorinated water, it kills the good bacteria in our stomachs leading to many intestinal disorders. Reports in the Journal Scientific American have linked chlorine in public water systems to rectal and breast cancer.

Exposure to chlorine diminishes vitamin E, vitamin C, and polyunsaturated fatty acids in our skin that makes one more sensitive to eye and skin irritations. It often leads to dry skin issues.

Chlorine is an active ingredient in bleach, in the form sodium hypochlorite (NaOCl). Chlorine dioxide (ClO_2) is used in bleaching paper pulp or white flour. It is a major ingredient in pesticides, fungicides, other chlorinated compounds like dioxin/furans and PCB's. Many other cancer-causing chemicals have chlorine in them. Women with breast cancer have 50-60% higher levels of organochlorines (chlorine by-products) in their breast tissue than women whom are cancer free. People whom bath in chlorinated water have a significantly higher risk of bladder cancer and people whom swim in chlorinated water have higher risks of asthma and allergies.

If we combine chlorine with ammonia, we get chloramines (monochloramine (NH_2Cl), dichloramine ($NHCl_2$), trichloramine (NCl_3)) depending on the acidity of the water. Chloramines are known to cause cancer in rats and the byproducts of chloramines are more toxic than those of chlorine. See Citizens Concerned About Chloramine (CCAC) http://www.chloramine.org for a more detailed list of health effects.

Chlorine in its anion form chloride readily combines with copper (Cu), mercury (Hg), zinc (Zn), lead (Pb), cadmium (Cd) and other heavy metals and makes them soluble and easier to absorb.
Gardening and Landscaping Problems Associated with Chlorine (Cl)

Chlorine levels in soils are low compared to other elements and they tend to decrease as one moves inland away from the coastline.

Chlorine is used in the process of photosynthesis; it raises osmotic pressure that affects the stomata, increases the hydration of plant tissue, believed to be related to the suppression of leaf spot and take-all diseases. It is considered an e ssential element for plants where it concentrates in the chloroplasts. Cereal grains absorb very little chlorine (10-20 ppm) while potatoes can contain over 5,000 ppm.

If chlorine levels in the soil drop below 2 ppm plant growth will suffer (extremely rare). Plants deficient in chlorine exhibit chlorosis of younger leaves and wilting of the plant. Plants that are deficient in chlorine are more likely to develop the disease "take-all".
If chlorine levels reach only 700 ppm in the soil, many plants begin to suffer (beans, apples, etc). Other plants like tobacco, tomatoes, cotton can tolerate levels as high as 3,000 ppm before suffering damage.

It is an essential growth element as it influences plant growth in several ways but not fully understood. Chlorine is required for strong stalks, it stimulates crops to grow, required for disease resistance, plays a role in photosynthesis, and regulates water movement in plants. Plants can absorb chloride by their roots or leaves.

Chlorine inhibits the growth of many microorganisms in the soil that help plants grow by disturbing their biological activity. Too much chloride (most common form is sodium chloride) in soil prevent plants from absorbing water.

Chlorine exists in the soil solution as chloride anion (Cl^-), thus the chloride anion competes with other anions required by plants. Too much chloride (think salt) in the soil prevents required nutrients like nitrate (NO_3^-) and sulfate (SO_4^{-2}) from being absorbed by plants, which starves them, making them more susceptible to insects and disease.

One of the most toxic forms of chlorine in landscaping and gardening is chloramines from our public water systems. Chloramines are highly toxic to fish, amphibians and other aquatic life forms (Note - Canada's EPA has ruled chloramines as toxic). If one overwaters their landscape, the water will enter our streams and may cause fish kills. If one has a pond in their landscape it may kill your fish as water from irrigation collects in the pond. Chloramines in the runoff from broken water mains enter our storm sewers and into our rivers and streams which kills the minnows and crayfish that eat the mosquito eggs and larva aggravating the mosquito problem.

Chloramines make the water acidic, which over time can change our soil pH. This may result in nutrient tie-up and create yellowing (chlorosis) problems in many plants. Chloramines prevent the absorption of other nutrients, which also may lead to yellowing.

The action of chlorine and chloramines kill bacteria both good and bad. Many good bacteria that live in the soil control fungal diseases. When we lose these good bacteria there is no natural control and turf grass diseases like "Brown Patch, Take All and St. Augustine Decline" become rampant. In other words the more one waters, the greater the chance that one will experience disease problems in their grass and other plants.

Chlorine and chloramines kill the nitrifying bacteria that fix nitrogen from the air into the soil. Hence, additional nitrogen must be supplied to the plants to replace the loss of free nitrogen from nature. Container plants (hanging baskets, pots, etc.) are more susceptible to damage from chloramines as they tend to require more watering. Other studies have shown that chloramines hurt the germination of seeds from many species of plants. Another problem caused by using artificial fertilizers is that chloramines can also be formed in the soil when ammonia (from artificial fertilizers, animal manures, pesticides, etc.) is combined with chlorine in the water.

Chloramines is neutralized in the soil by chemical reactions with organic matter (humus) which is destroyed in the process. Organic matter in the form of humus can hold 15 times its weight in water, hence every time we water with municipal water, the soil loses some of its ability to hold and store water. Chloramines hurt the production of compost tea as it kills off some of the microbial species that one is trying to grow to high densities. Note: One teaspoon of humic acid (liquid form of humate) can neutralize the chloramines in 100 gallons of water depending on the exact concentration of chloramines.

Using high humus products like a quality compost, native mulches (that have been composted) and humate in ones landscape is the easiest way to minimize the damage from chloramines and chlorine. This ensures that even if some of the organic matter is destroyed and some of the beneficial microbes are killed, there is plenty left over so the soil life can quickly regenerate and prevent problems.

Sources:

Chloride toxicity often occurs after application of potassium chloride (KCl) which is also known as muriate of potash and used in artificial fertilizers. Dairy and feedlot manure can have 50,000-100,000 ppm of salt (sodium chloride). Most poultry manure is another source of salt along with sewage sludge (bio-solids). Spent mushroom substrate (mushroom compost) is generally very high in salt but it varies greatly around the world. Other sources include manure based compost, Biosolids compost, municipal water supplies, artificial fertilizers, some organic fertilizers made from poultry manure, thunderstorms and storm water run-off from roads treated with salt, burning coal, and ammonium chloride (NH_4Cl) is also used in artificial fertilizers.