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NEWS FROM THE WONDERFUL WORLD OF SOIL AND PLANTS

MINERALS - The Elements and What They Do

Today we continue with our study of all the minerals (elements) in the human body, what they do, with a look at elements number 7, 8, and 9 on the Periodic table. See previous newsletters (9/17/21 and 9/24/21) for a list of references and introduction to the Periodic Table.

7) **Nitrogen (N)** - Every gardener knows that nitrogen is essential for plants to grow and be healthy. Every living thing needs nitrogen, and it is a key component of tens of thousands of molecules, some of which are highly reactive (think explosives).

Nitrogen can be found in igneous rocks at 20 ppm, in healthy fresh water at 0.23 ppm, seawater at 0.5 ppm, 1,000 ppm in humus, marine plants at 15,000 ppm, land plants at 30,000 ppm, land animals at 100,000 ppm. Human blood has 34,000 ppm (3.4%) while bone can have 43,000 ppm (4.3%) and similarly for other animals. This is why blood meal and bone meal work so well as an organic fertilizer.

However, our major supply of nitrogen is the atmosphere, which is 78% nitrogen or four million billion tons! The problem or issue is that the nitrogen in the air is in the form of a nitrogen atom very strongly chemically bonded to a second nitrogen atom (N_2), which is extremely inert and essentially useless to plants, animals and almost all life in this form.

On our earth, nitrogen occurs in many forms that are useable by plants and animals that one will recognize:

Nitrogen oxide (NO) - helps to help relax blood vessels and help prevent heart attacks, the nitric oxide producing enzyme (NO-synthase) is abundant in the brain

Nitrite (NO_2^-) - is easily converted into nitrosamines, which are known carcinogens

Nitrate (NO_3^-) - which we recognize as a plant nutrient

Notice how adding additional oxygen atoms (O) change the properties of the nitrogen molecule or ion above.

When N combines with carbon and hydrogen it can form hydrogen cyanide (HCN) which is highly toxic. If two atoms of nitrogen are combined with oxygen (N_2O) we get laughing gas which is used as a propellant in items like canned whipped cream.

When nitrogen is in the form of ammonium nitrate (NH_3NO_3) a common artificial fertilizer, it is highly explosive (remember the Oklahoma City Bombings or the explosions at the fertilizer plant outside of Waco a couple years ago). It is also a component in gunpowder, trinitrotoluene (TNT) and nitroglycerine.

Nitrogen boils at -320.8 ^{0}F (-196^0 C), hence it is often used as a cryogenic cooling liquid; dermatologists often use liquid nitrogen to freeze cancerous spots or growths on our skin.

All life requires nitrogen (N) as it functions as a structural atom in proteins, amino acids, nucleic acids like RNA and DNA and a wide variety of organic molecules. When in a more reactive form such as ammonia (NH_3) it is caustic and hazardous, however when diluted with water in becomes a common cleaning agent. If we add an extra hydrogen atom (H) it becomes a fertilizer component (NH_4^+) we know as ammonium.

Gardening and Landscaping Problems Associated with Nitrogen (N)

In gardening, plants use a lot of nitrogen often reaching 3% of plants total compounds. Nitrogen accounts for 16-18% of a plant's amino acids and proteins and it is required for leaf growth.

We have seen that nitrogen is an extremely important atom in everything we do and in the world around us. So how do we get nitrogen in the air (N_2) which is inert and essentially useless, into a form that plants, animals, and humans can use?

Most of the nitrogen that we can use starts with bacteria in the soil and algae in the oceans, that have the ability to break apart the extremely tough chemical triple bond found in the inert N_2 molecule. These microbes are the primary "fixers" of nitrogen that convert nitrogen from the air into a form that plants and animals can use.

All gardeners know that plants we call "legumes" are specialists in attracting bacteria with the enzymes called nitrogenase that are required to fix nitrogen. Many species of blue-green algae also contain this enzyme and can fix nitrogen. However, for algae in the soil to fix nitrogen they require the element molybdenum (Mo) be present which is used as a catalyst. The other common but lesser source of useable nitrogen occurs during thunderstorms where lightning breaks the triple bond of the nitrogen molecule in the air and allows the nitrogen to be absorbed into rainwater. This is why many plants look more vigorous after a summer rain shower as the leaves absorb the nitrogen.

NOTE: As we continue through each of the elements, we will see that many processes in soil, plants, microbes, animals, and humans require or are dependent upon the presence of other elements as seen in the example above. The out-of-date assumption that plants only need 16 elements is why we have so many problems in horticulture and agriculture to health problems in animals and humans.

Nitrogen is the most mis-used of all the fertilizer elements. Research at Oregon State University in 1996, by Dr. Elaine Ingham a soil microbial ecologist, completed studies on over 6,000 soil samples from around the world. She has found that in ALL cases, all

nitrogen (N) inputs to the soil feed the microbes first. This means that microbes must process ALL nitrogen inputs (synthetic or organic) *before* plants can use it. The useable nitrogen is in the "manure" produced by the microbes or given directly to the plant by the microbes in healthy soils!

Starting in 1998, research showed that excess nitrogen creates weak succulent growth that: attracts insects and pathogens, pollutes groundwater, causes fruits to crack, creates bitter pits, causes tip burn of leafy vegetables, increases tomatoes blossom end rot, browning of cauliflower curds, new growth dieback, and drooping flowers on roses.

Water-soluble nitrogen from synthetic fertilizers pushes tissue growth; however, other essential nutrients cannot be absorbed from the soil profile fast enough to keep up even though they may be available in the soil. This process leads to an out of balance condition that weakens plants creating susceptibility to insects and disease.

Even as far back as 1999 we started learning that the form of nitrogen provided to plants was important to their health. There was a paper published in the Journal of Environmental Horticulture where they found that Azalea Lace Bugs were attracted to Azaleas fed with artificial fertilizers.

Other researchers have found that the chemical form of nitrogen supplied to plants affects protein synthesis. Nitrogen supplied from synthetic sources (artificial fertilizers) results in lower protein content than the same amount of nitrogen from natural sources. Additional studies have found that nitrogen supplied from synthetic sources results in much higher rates of disease and attracts pest insects. It was also been found that excessive availability of nitrogen derived from synthetic fertilizers can delay maturity of many plant species.

For gardeners yellowing leaves may be a sign of nitrogen deficiency. A couple studies have found that Texas soils require less nitrogen than soils anywhere else in the United States. Excess nitrogen creates a chemical imbalance that hurts plant growth.

The leaves become dark green, excessive weak succulent growth with weakens plant fibers along with reduced sugar content which attracts insects and leads to delayed crop maturity.

Nitrogen excess from artificial fertilizers has been found to lower health promoting beneficial phenols normally found in vegetables.

Nitrogen as nitrate (NO_3^-) from artificial fertilizers is very water-soluble, this means it leaches very easily from the soil polluting our ground water, streams and even the air we breathe. This nitrogen loss leads to algae blooms in our streams, the algae bloom then consumes the available oxygen. Without oxygen, minnows, crayfish, and other aquatic life die which allows a mosquito's entire larva to develop since they are not being eaten anymore. Now we have an increase in our mosquito problems and the diseases they carry.

Bacteria have 5 carbon atoms to every nitrogen atom in their bodies (C:N), what is called a 5:1 ratio. In nature a lack of dissolved nitrogen in the water limits the growth of pathogenic bacteria. Now with the extra nitrogen pollution from artificial fertilizers these pathogenic bacteria can grow to extremely high levels in our bayous and streams.

In addition, elevated levels of nitrogen as nitrate (NO_3^-) constitute health hazards to both humans and animals. It takes almost 300 carbon dioxide molecules to cause the same amount of global warming as one molecule of nitrogen oxide (N_2O). The largest source of this greenhouse gas is artificial fertilizers (CSA News April, 2017).
Soil microbiologists have found that most of the plant species we call weeds have to have their nitrogen in the nitrate form (NO_3^-), while most of our perennial plants from flowers to trees require their nitrogen in the ammonium form (NH_4^+). Hence nitrate based artificial fertilizers select for weedy species over our desired perennials.

The most useful forms of nitrogen are found in organic matter where the nitrogen is released through microbial activity. Recently it was discovered that trees can also get nitrogen from fungi that take it directly from nitrogen rich rock minerals.

Sources: compost, organic fertilizers, rain, air, microbes, blood and bone meal, animal tissue such as feathers or meat, aged native mulch.

8) **Oxygen (O)** - An often overlooked but extremely important element when dealing with soils and plants. It is the third most abundant element in the universe and makes up 20% of the atmosphere, more than a million billion tons. It is the most abundant element on earth accounting for half of the weight of the earth's crust and 86% of the weight of the water in our oceans.

Oxygen is found in igneous rocks at 464,000 ppm, shale at 483,000 ppm, sandstone at 492,000 ppm, limestone at 497,000 ppm, fresh water at 889,000 ppm and seawater at 857,000 ppm, soils at 490,000 ppm, and land plants at 410,000 ppm.

Oxygen has the ability to oxidize (rapid as in a fire or slow and gentle in our bodies). It is often called the "fuel of life" as the reaction of oxygen and carbon releases energy whether it is in our fireplace, our bodies, or in microbes in the soil. It is a byproduct of photosynthesis that is performed by plants that we cannot live without.

In the atmosphere, oxygen binds with itself to form a molecule in air (O_2). It is one of the major building blocks of all organic compounds (carbohydrates, proteins, fats, and nucleic acids (DNA and RNA)). Oxygen becomes a major building block of soils when combined with silicon (SiO_2). Half of the known elements that are found in nature combine with oxygen to form minerals we call oxides. The crust of the earth is composed of silicon-oxygen minerals.

A few of these are familiar to gardeners as rust or iron oxide (Fe_2O_3), carbonates (CO_3^{-2}), silicates (SiO_4^{-4}), phosphates (PO_4^{-3}), or potassium nitrate (salt peter) (KNO_3). Other forms of oxygen we all know are hydrogen peroxide (H_2O_2) or ozone (O_3). When oxygen occurs in the atmosphere in the form of ozone, it absorbs dangerous ultraviolet radiation protecting us from excessive skin damage. The human body is 60% water (H_2O) and oxygen is 61% of our total body mass.

Gardening and Landscaping Problems Associated with Oxygen (O)

Oxygen is so important that 43-45% of all the compounds in a plant contain oxygen. A healthy soil is 25% air of which oxygen is the critical ingredient required by microbes and plants. Adding oxygen to soils often creates an immediate growth response, a lack of oxygen creates conditions in which diseases, and pests thrive. A lack of oxygen also encourages weed seeds to germinate. Most pathogenic organisms whether human or plants are anaerobic and do not like oxygen. Oxygen is critical for all beneficial biological processes in the soil. This is why aeration by microbes and earthworms is so important. We do not want to kill them by using toxic chemicals.

It is interesting that the enzyme nitrogenase requires a low oxygen environment to work; the plant keeps its oxygen levels low at the root nodule by binding oxygen to a specialized protein called leghemogloblin. It is a delicate balancing act, as plants have to keep oxygen levels low enough for the enzyme to work but high enough to keep the bacteria alive.

Note: Oxygen does not function well in our soils or our bodies if there is a deficiency of selenium (Se).

Sources: compost, aged native mulch, water (H_2O), air (O_2), hydrogen peroxide

9) **Fluorine (Fl)** - Fluorine is the 13th most abundant element in the earth's crust. Fluorine is found in igneous rocks at 625 ppm, shale at 740 ppm, sandstone at 270 ppm and fresh water at 0.09 ppm, seawater at 1.3 ppm and soils at 200 ppm. Land plants contain from 0.5 to 40 ppm, marine plants at 4.5 ppm, marine animals at 2.0 ppm, and land animals at 150-500 ppm for the soft tissue and 1,500 ppm in bones and teeth. Fluorine is an essential element for animals and humans.

Fluorine is the most reactive of all the elements and is a pale-yellow gas under normal conditions. Many people are confused by the term's fluorine and fluoride. Simply put fluorine is the element and fluoride is the negative ion of the element fluorine (F^-) which is the form in which it combines with other elements. If calcium combines with fluorine, we call it calcium fluoride (CaF_2) and it is the soft colorful mineral we find nature that we call fluorite.

Fluoride is a component of many products and used in manufacturing to produce other products. Fluorine was used to separate uranium isotopes to make atomic bombs and the Nazi's used chlorine tri-fluoride (ClF_3) as an incendiary agent in flame-throwers.

Fluorine (C_8F_{17}) is used to make water repellant coatings for fabrics to anti-stick products like Teflon, which contains perfluorooctanoic acid (PFOA) where the "F" stands for fluorine.

Even though fluorine is useful, both fluorine and fluoride are dangerous. Fluorine gas is extremely toxic and breathing it in concentrations as low as 0.1 % for only a few minutes will kill. Fluoride itself is less toxic although it too is highly poisonous. It is so poisonous it is used as an effective insecticide for cockroaches and ants. Over 150 pesticides contain fluoride due to its extreme toxicity. Fluoride is listed as a major chemical warfare agent by the USA military due to its extreme toxicity. Yet, we add it to our water supply.

Even though fluorine is an essential element for animals and humans, it cannot be too much or too little, and it must be in balance with other nutrients. For example, studies have shown that too little fluoride or too much increases the risk of hip fractures. Clinical toxicity is observed as dental fluorosis at 8-20 ppm and chronic systemic toxicity appears when fluoride levels reach 20-80 mg per day over several years. A 1977 study found that there were 10,000 excess cancer deaths per year caused by fluoridation of some water systems. In 1990, an animal study on fluoride found an increase in precancerous lesions in mucus membrane cells, an increase in cancers of oral mucus membranes at double the rate for males compared to females, an increase in thyroid follicular cell tumors and liver cancer.

Fluoride has powerful effects on required enzymes, effectively blocking their activity. Over 72 enzymes are inactivated or destroyed by fluorinated water. Due to its toxic nature, fluoride is often used in drugs and pharmaceuticals. Fluoride is used in many antidepressants of the Selective Serotonin Reuptake Inhibitors (SSRI) type (ex. Prozac or Zoloft).

Increased aluminum (Al) levels in our bodies have been associated with Alzheimer's disease; fluoride helps the body absorb aluminum. A recent study in Ireland found that there was a link of fluorosis and cardiovascular disease ("Dental Fluorosis is a biomarker for coronary heart disease (CHD)", 2013, Takamori). Professor Takamori's research team observed that children with dental fluorosis have a higher incidence of heart damage and an increase in abnormal heart rhythm than those without fluorosis.

If one looks at the periodic table of the elements presented earlier in this series, you will notice that Fluorine is in the same column (2nd from the right) as Iodine (I) which means it has very similar chemical properties. Hence, fluorine competes with and replaces iodine, especially in the thyroid gland, which is a contributing factor to thyroid cancer.

Fluoridation of water increases human and animal absorption of lead, which is associated with many physical and mental problems. Elevated fluorine levels are associated with increased risk of several types of cancer. The National Toxicology Program has concluded based on "the preponderance of evidence" that fluoride chemicals are mutagenic meaning they inflict genetic damage that can trigger cancer. New research published in the Journal of Environmental Health has found that artificially fluoridating public water supplies with the toxic waste byproducts of aluminum and artificial fertilizer production is directly linked to the rising rates of learning disabilities like ADHD, decreased thyroid function and lowered IQ.

Other sources include bone meal (which can contain 1,000 ppm of fluoride) or sodium fluoride (NaF) which is considered an inert substance by the EPA and allowed in the Organic Standards and used in many common products.

Other sources of fluoride are found in wine and grapes due to the fact that many pesticides (over 150) contain fluoride due to its extreme toxicity. This is why eating conventional produce is a major source of fluoride due to pesticide residues and another reason to "go organic".

Gardening and Landscaping Problems Associated with Fluorine (F)

Fluoride may be tightly bound to some types of clays and accumulate over time. Too much fluoride retards the growth of plants and reduces crop yields. Corn, maize and apricots are very sensitive to fluoride while asparagus, beans, cabbage, carrots are resistant. In some fluoride rich soils, the grass grown on them is toxic to livestock.

We find that some types of perlites are high in fluoride and must be leached before use. Other products like super phosphate fertilizer are made from the mineral apatite which is high in fluoride (another reason not to use artificial fertilizers). The waste

product from the phosphate fertilizer production is hexafluorosilicic acid along with other toxics like arsenic, lead and small amounts of radioactive elements (and this is what is added to our drinking water).

Fluorine affects plant metabolism in many ways: reduces oxygen uptake, causes respiratory disorders, assimilation decreases, reduction in chlorophyll content, inhibits starch synthesis, inhibits pyrophosphatase function (prevents plants from utilizing phosphate properly), alters metabolism of cell organelles, injures cell membranes, disturbs DNA and RNA, causes synthesis of fluoroacetate (an extremely toxic compound).

High levels of fluorine destroy soil organic matter and humic mineral complexes, destroy many enzymatic activities of microbes, and prevent nitrogen fixation by microbes. As little as 0.5 ppm will suppress the natural immune system of plants.

Fluoride is an ion, and generally remains in solution and plants are exposed to this chemical by water, air and soil. Fluoride is a poison that accumulates in plant foliage and often leads to toxicity symptoms on sensitive plants. Additionally, it strongly inhibits photosynthesis and other processes in the plant. It is absorbed by the roots (or stomata) and moves through the plant accumulating in the leaf margins. As we continue to water our landscapes with municipal water this poisoning slowly happens over time thus, we may not realize why are plants are getting sick and declining or just die suddenly. In previous issues of the newsletter, there are several additional and more detailed articles on fluoride and plant health (10/31/14, 6/19/15, and 8/25/15) and many more since then.

We now know that the studies showing fluoride to prevent cavities were falsified by the companies wanting to get rid of an industrial hazardous waste resulting from the manufacture of aluminum and phosphate fertilizer production, saving them billions of dollars in disposal costs of a hazardous waste.

Sources: tooth paste, sewage sludge, bone meal (up to 1,000 ppm of fluoride), some super phosphate fertilizers, burning coal is an airborne source of fluoride, contamination of our soils water from municipal water supplies, pesticides.