www.natureswayresources.com

JOHN'S CORNER:

MINERALS - The Elements and What They Do (Part 3)

by John Ferguson

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.

101 Sherbrook Circle • Conroe, Texas 77385-7750
(936) 321-6990 Metro • (936) 273-1200 Conroe • Fax (936) 273-1655

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 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.

In gardening, plants use a lot of nitrogen often reaching 3% of plants total compounds. Nitrogen accounts for 16-18% of a plants 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 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. A lack of dissolved nitrogen in the water limits the growth of pathogenic bacteria in nature. Now with the extra nitrogen pollution from artificial fertilizers these pathogenic bacteria can grow to extremely high levels.

In addition, elevated levels of nitrogen as 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. 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^+).

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.

101 Sherbrook Circle • Conroe, Texas 77385-7750
(936) 321-6990 Metro • (936) 273-1200 Conroe • Fax (936) 273-1655

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

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).

The human body is 60% water (H_2O) and oxygen is 61% of our total body mass. 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. Sources: compost, water (H_2O), air (O_2), hydrogen peroxide.