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JOHN'S CORNER:

MINERALS - The Elements and What They Do (Part 29)

by John Ferguson

41) Niobium (Nb) - It is 34th most common element in the earth's crust and is relatively common. It is a soft grayish ductile metal of group 4 on the Periodic table.

It is a component of the minerals pyrochlore and columbite. This element is named after Niobe the daughter of Tantalus (element tantalum) and son of Zeus of Greek mythology. The name reflects the great similarity between the two elements in their physical and chemical properties, making them difficult to distinguish. They are often found together in nature with the highest concentration in acidic igneous rocks.

Niobium is found in igneous rocks at 20 ppm, shale at 11 ppm, and limestone at 0.3 ppm. Very little is found in fresh or seawater. Land plants average 0.3 ppm and marine animals only 0.001 ppm.

Niobium has a +5 valence or electrical state and has a great affinity to associate with iron (Fe), titanium (Ti), and zirconium (Zr).

Niobium is used mostly in alloys, the largest part in special steel such as that used in gas pipelines. Although these alloys contain a maximum of 0.1%, the small percentage of niobium enhances the strength of the steel. The temperature stability of niobium-containing super alloys is important for its use in jet and rocket engines as it resists corrosion at high temperatures. It is also used in surgical implants, coins, and jewelry. At room temperature, it is very resistant to most acids.

Niobium is used in various superconducting materials. These superconducting alloys, also containing titanium and tin, are widely used in the superconducting magnets of MRI scanners.

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In soils, the weathering of the various niobium containing minerals determines its mobility and availability in soils. Increased levels of organic matter in the soil increase the availability of niobium.

We find small amounts of niobium in human blood, kidneys, lungs, muscle, and testes. Metallic niobium has low toxicity since it is poorly absorbed in our digestive system.

Gardening and Landscaping Problems Associated with Niobium (Nb)

Niobium is relatively mobile under humid conditions and therefore available to plants. It is relatively common in most all plants at very low levels.

Some plants that are members of the *Rubis* family (blackberries, dewberries, raspberries, etc.) can have 10 ppm in their tissues. Mosses and lichens often accumulate 0.5 ppm although the role is unknown.

In some banana fruits, 320 ppm has been found.
Sources: granite sand, basalt sand

42) Molybdenum (Mo) - This little known trace element is essential to nearly every life form on Earth. The amount that is in our food is directly related to how much is in the soil in which the plants grow. Molybdenum is a lustrous silvery metal that is soft when pure. It occurs in nature at the +6 or +2 electrical or oxidation state. It occurs in igneous rocks at 1.5 ppm, shale at 2.6 ppm, sandstone at 0.02 ppm, limestone at 0.4 ppm, and very little in fresh or seawater. In soils, it averages 2 ppm where it is strongly concentrated by humus. Marine plants have 0.45 ppm, land plants have 0.9 ppm, marine animals from 0.6-2.5 ppm, and land animals at 0.2 ppm.

Molybdenum is different from many other nutrients as its solubility (availability) decreases as the pH becomes lower or more acidic. It is more available in alkaline soils hence its availability is very sensitive to pH, oxygen, and drainage issues.

When molybdenum is added to steel, it produces an alloy that can be used to make tools from drills to armor for military tanks. If combined with sulfur (S) it forms a lubricant that can withstand very high temperatures. Molybdenum is used in many types of electronic products and in automobile to aircraft parts.
Small amounts of molybdenum are essential for all life but the function and requirements not fully understood by scientists.

Over 50 enzymes require molybdenum to work properly where it functions as a co-factor, a few of these are:

Sulfite oxiase - helps build proteins
Xanthine oxidase - multiple functions
Aldehyde oxidase - helps metabolize drugs and toxins
Mitochondrial amidoxime (helps body remove toxic substances)

It is also used as a catalyst for enzymes that breakdown fats, carbohydrates and certain amino acids.

A deficiency of molybdenum can lead to headaches, rapid heartbeat, mental health issues, and even coma, problems with uric acid production, and decreased metabolism of sulfur containing amino acids.

Tooth enamel contains high amounts of molybdenum that suggests it might help prevent tooth decay.

In areas where there is low molybdenum in the soils (and foods), the lack has been associated with cancer of the esophagus and stomach (10X higher rates).

The Linus Pauling Institute has found that sufficient molybdenum helps in the treatment of certain forms of cancer.

When molybdenum is present in the soil it prevents the production of cancer-causing agents know as nitrosamines in plant foods. In animal studies, it prevents pulmonary and liver fibrosis and reduces damage to liver and the heart from antibiotics.

Though rare, too much molybdenum in our system (mammals) can cause a copper (Cu) deficiency known as *molybdenosis,* while low molybdenum intake can cause copper toxicity.
These effects vary with species, breed, and sex. There is also a molybdenum-sulfur relationship although not as strong.

Molybdenum is generally not stored in body as it is easily absorbed and excreted via urination.

Certain beneficial microorganisms that are involved with nutrient uptake require molybdenum where it is used in electron transfer reactions. Molybdenum availability is related to other nutrients and the chemical complexing of those nutrients. As in mammals, it is required for certain physiological processes such as enzyme and co-enzyme systems (i.e. nitrate reductase enzyme and sulfite oxidase).

Good food sources are pork, lamb, and beef liver. Of the vegetables and fruits, legumes have the most molybdenum.

Gardening and Landscaping Problems Associated with Molybdenum (Mo)

Molybdenum is a trace nutrient and most plants require 0.01-10 ppm. Molybdenum is involved with nitrogen (N) metabolism of plants where it is essential for the conversion of the ammonium (NH_4^+) cation to nitrate (NO_3^-) anion. Nitrogenase is involved with converting the nitrate (NO_3^-) anion into the ammonium (NH_4^+) cation.

It is a structural component of the enzyme nitrogenese which has significant effects on pollen formation (used in reduction of nitrates for the formation of proteins). It also helps plants use nitrogen, and a shortage of molybdenum leads to inefficient utilization of nitrogen leading to increased risk of nitrate (NO_3^-) leaching and the polluting of ground water.

As in plants, molybdenum is involved with nitrogen fixation by azotobacteria and non-symbiotic nitrogen fixing bacteria. In 2009, it was recognized that molybdenum was the limiting factor in forest growth, not phosphorous (P) as previously believed. Nitrogen uptake by trees depends on soil bacteria

converting atmospheric nitrogen to ammonia and these bacteria require molybdenum to work! Most phosphate fertilizers contain molybdenum hence researchers were confused.

If deficient in molybdenum, plants often appear as if they are nitrogen deficient.
The earliest symptoms occurs on youngest leafs and stems, where it is more common on acid sandy soils, and in humid regions. On some plants, there is an irregular artistic pattern of leaf yellowing, where the veins remain green, and the area in between turns yellow.

Legumes are more susceptible with marginal scorching and cupping or rolling of leaves, and irregular leaf blade formation known as whiptail in brassicas crops. Legume plants tend to have more molybdenum than other plants with levels up to 350 ppm without any toxicity symptoms.

Most artificial fertilizers tend to acidify the soil preventing molybdenum from being absorbed which then leads to an antagonistic relation with manganese. To correct the problem the soil needs to have lime applied to raise the pH.

Molybdenum is critical for "grasses" and other crops requiring little potash. Molybdenum like boron (B) is absorbed by plants as an anion not a cation as most other nutrients.
The amount in plants tends to increase as the soil pH increases. The primary form of molybdenum in the soil is the soluble form called molybdate $(MoO_4)^{-2}$ anion, where the absorbability is increased 10X for each unit increase in pH.

Sources: compost, native mulches, most organic fertilizers, rock dusts, Biosolids (sewage sludge), some coal ash

43) Technetium (Tc) - Technetium is a silvery-grey, radioactive transition metal in-group 7 of the periodic table. Considered an artificial metal used in metal processing. It is mainly used in alloys of molybdenum (Mo) and niobium (Nb) where it exhibits super conductivity and is very resistant to oxidation.

This element is produced by the spontaneous fission of uranium (235) in nature. Hence, it is often found in uranium ores. It was also deposited in soils from fallout from worldwide nuclear testing. The most stable electrical or oxidation states are +7 and +4. It is absorbed in significant quantities only in soils high in organic matter. The chemical properties of technetium are very similar to manganese (Mn) since it is located directly below manganese on the periodic table.

Technetium has no biological role, as it does not occur naturally in the biosphere. Almost all technetium is created artificially as very little is found in nature. It is only considered toxic due to its radioactive properties. In rodent studies, it was not found to accumulate in their bodies even though they were fed large doses. In humans, it is poorly absorbed and we rapidly excrete it in our urine. Isotopes of technetium are widely used in medicine for the diagnostic of thyroid disorders and other medical x-ray diagnostics (isotopes have the same numbers of protons and electrons but different numbers of neutrons in the nucleus of the atom).

Gardening and Landscaping Problems Associated with Technetium (Tc)

Technetium is easily absorbed by plants as the anion $(TcO_4)^-$ though extremely rare. In plants, technetium does not move around with the highest concentrations occurring in older plant tissues.

Organic fertilizers inhibit its phytoavailability.
Sources: radioactive fall-out

44) Ruthenium (Ru) - It is a hard lustrous silvery-white metal in the platinum group. It is found in igneous rocks at 0.001 ppm, and plants at 0.005 ppm, and land animals at 0.002 ppm and is one of the rarest metals on earth and is considered a precious metal. Ruthenium oxide (RuO_4) is highly toxic.

Used in various electrical components due to its ability to resist corrosion. It is used in some types of solar cells. A few radioactive isotopes are also used in medicine.

The most common usage is in jewelry along with platinum.

It has no known biological role and the amount in the human body is so small to be almost immeasurable.

Gardening and Landscaping Problems Associated with Ruthenium (Ru)

The amount of ruthenium in most plants is less than 5 ppb, but some species of algae concentrate it.
Sources: Ores of platinum metals, some nuclear reactors