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JOHN'S CORNER:

MINERALS - The Elements and What They Do (Part 32)

by John Ferguson

48) Cadmium (Cd) – Cadmium Is a silvery metal that will tarnish in air (like silver). It will dissolve in acids but not in alkalis. It is a heavy metal that damages all cells in the human body.

It is found in igneous rocks at 0.2 ppm, shale at 0.3 ppm, sandstone at 0.05 ppm, and limestone at 0.035 ppm. It occurs in fresh water at 0.08 ppm and seawater at 0.00011 ppm (fresh water is slightly acidic and seawater is slightly alkaline). Coal can contain 0.05- 175 ppm.

In marine plants, we find 0.4 ppm and land plants at 0.6 ppm. However, in marine animals, the cadmium will bioaccumulate and ranges from 0.15 to 3.0 ppm, which is one of the reasons why there is little cadmium in seawater. In land animals, we see 0.5 ppm where it tends to accumulate in the kidneys.
Cadmium has a +2 electrical or oxidation state, which is the same as zinc which cadmium mimics in nature as it is in the same column on the periodic table. Cadmium is rarely found in nature in a pure form but combines easily with many other elements.

Cadmium is used in batteries (Ni-Cd) to televisions and many other electrical devices. Cadmium telluride is used to make solar panels. Cadmium sulfide is used to make a yellow pigment. A lot of cadmium coated bolts and nuts are used on airplanes, as it is extremely resistant to corrosion.

Cadmium is found in the bodies of microorganisms that live in the soil. Some-microbes have the ability to hyper-accumulate cadmium. Some actinomycetes strains can have 1,120 ppm in their tissues.

Cadmium is not required for the majority of life forms. However, a marine diatom *Thalassiosira weissflogii* produces a cadmium specific enzyme which catalyses the conversion of carbon dioxide and carbonic acid.

Cadmium is highly toxic if we have too much, where it will damage kidneys and other organs (in high levels it is also toxic to plant tissue). The human body tries to remove cadmium from our bodies by transporting it to our kidneys in an attempt for it to be eliminated. However, in binds tightly to many enzymes and can be stored for over 30 years! Cadmium replaces zinc and binds over 300 times tighter to the enzymes. This is why having sufficient zinc in our diets is very important as it prevents most cadmium from being absorbed. For a more detailed discussion, see page 90-91 in " Nature's Building Blocks - An A-Z Guide to the Elements, John Emsley, Oxford University Press, 2011, ISBN 978-0-19-960563-7".

All types of *artificial* fertilizers appear to increase cadmium levels in our soils. Phosphate rocks from which we get phosphorous for artificial fertilizers often has lots of cadmium in it. For example, a source of phosphate rock from Morocco can have over 50 grams per ton (an extremely high amount of cadmium).

Cadmium contamination is increasing in our soils from airborne deposition where the main sources are metal smelters, volcanic eruptions, burning of coal and burning of municipal waste (garbage).

If our soils contain the salt sodium chloride (NaCl), it stimulates the formation of cadmium-chloride complexes, which are very soluble and phytoavailable. One should not use high salt products (poultry manure fertilizers, cow manure, etc.) along the Gulf Coast, as many of our soils are already high in salt. Any food crop from vegetables to fruits will absorb more cadmium that we do not want in our bodies. Chlorine also comes from municipal water systems and becomes available to form cadmium-chloride molecules when we water our lawns and gardens if one has used artificial fertilizers.

Cadmium in our bodies interferes with the mechanisms responsible for DNA repair and it disrupts mitochondrial activity leading to many degenerative diseases. The World Health Organization recognized cadmium as a carcinogen.

The book " Chemical Exposure and Human Health, Cynthia Wilson, McFarland Publishers, 1993, ISBN: 0-89950-819-3" lists hundreds of health issues associated with excess cadmium in our bodies.

Gardening and Landscaping Problems Associated with Cadmium (Cd)

Cadmium content in plants is directly related to the amount in our soils and as little as 3 ppm will depress growth in many species of plants.

Symptoms of cadmium toxicity are leaf chlorosis and necrosis. This is followed by leaf abscission as cadmium interferes with photosynthetic processes and the uptake and absorption of other required nutrients.

Some plants like turnips and leafy vegetables like spinach will absorb enough cadmium to be a health risk. Cadmium contamination is much higher in vegetables grown with artificial fertilizers. Many of the synthetic nitrogen sources are strong acidifiers (why farmers have to lime their fields) which causes the plant to absorb more cadmium. In addition, cadmium stimulates the growth and hatching of nematodes (cysts) in the soil.

Some mushrooms (fungi) can have 30 ppm in their tissues even when growing on soils with only 0.3 ppm cadmium. Tobacco plants tend to absorb larger amounts of cadmium and is one of the reasons smoking causes cancer.

If you notice that cadmium is directly below zinc in the periodic table, hence it has similar chemical properties. Thus, a zinc deficiency in the soil can lead plants to absorb more cadmium.
Lettuce grown on agricultural fields where Biosolids (sewage sludge), where once applied, can have over 30 ppm of cadmium.

Coal can have very high levels of cadmium, which become concentrated in the ash when coal is burned for fuel. Many companies use the extreme alkalinity of coal ash to chemically burn the mulch made

from raw wood black. Coal as is also used to burn pine bark black to mimic aged (partially composted) pine bark.

Sources: rubber tire mulch, sewage sludge (Biosolids) and compost made from Biosolids, black mulch treated with coal ash, some artificial fertilizers

49) Indium (In) - Indium was named for the strong indigo-blue spectral emission line produced when heated. Indium is soft and silvery, a good conductor of electricity and a fun metal. When bars or rods of indium are bent, they "cry" producing a crackling sound.

Indium is found in igneous rocks at 0.5-1.0 ppm, shale at 0.1 ppm, sandstone and limestone at 0.05 ppm. In land animals, indium averages 0.016 ppm.

The electrical or oxidation states of Indium range from +1 to +3 with +3 being the most common. Indium often forms compounds with iron (Fe) and manganese (Mn) hydroxides. Indium is often found in nature in association with sulfide minerals hence indium is oft
en recovered from the mining of other minerals. Indium is also found in coal and in some crude oil.

Indium is used alloys, solders, many types of electronics, coatings of high-speed bearings, transistors, and photoconductors. A common usage is in making touch screens. Indium oxide is used to make LCD televisions and computer monitors as it bonds to glass, is transparent and conducts electricity. Indium is a super conductor and many of its alloys with other metals are used to make super conducting materials. My research in graduate school on superconductivity was published as a small book titled "Magnetization Studies of Superconducting Ternary Alloys of Lead, Indium, and Tin". Indium is not known to have any biological function in humans. However, its salts in small doses, stimulates metabolism. If even a few milligrams are consumed it will cause a toxic reaction in our kidneys, heart and liver. In high amounts, it causes focal necrosis in the liver.

However, indium compounds have been found to be an effective treatment for the disease called "sleeping sickness".

Gardening and Landscaping Problems Associated with Indium (In)

Indium occurs in soils in a form that could readily be absorbed by plants, however, that does not occur. Most plants have only 1-2 ppm of indium in their tissues.

If indium levels are 5-9 ppm in soils, it inhibits the activity of nitrogen fixing bacteria to fix nitrogen. Indium toxicity in plants can occur in acidic soils where the symptoms are similar to aluminum (Al) as both are in the same column on the periodic table with similar properties.

Indium has been found to stimulate growth of plants in laboratory cell cultures.
Beets grown in soils amended with sewage sludge have 80-300 micrograms per kilogram.
Sources: sewage sludge, compost from sewage sludge (Biosolids)

50) Tin (Sn) - Tin is a silvery white metal that is soft and pliable. It becomes unreactive in air and water as a thin film of oxide forms preventing additional reactions, however tin will dissolve in acids and bases.

Tin is found in igneous rocks at 2 ppm, shale at 6 ppm, sandstone and limestone at 0.05 ppm and very little in fresh or seawater. In soils, tin ranges from 2-200 ppm as it is strongly absorbed by humus.

Most land plants have 0.3 ppm and marine plants at 1 ppm. Marine animals have 0.2-20 ppm tin and land animals only 0.15 ppm. The mobility of tin is directly related to the pH of the soil.
Tin is complexed by organic matter hence it can accumulate in some soils. Tin is absorbed by plants where it accumulates in the roots but very little is translocated to above ground parts of a plant.
Tin was first used to harden copper to form bronze, over 5,000 years ago which led to the development of civilizations called "The Bronze Age". Glass when applied to molten tin would not stick thus providing a way to make perfectly smooth glass for windows. Tin is used to make cans and as a coating on metal cans since it is non-corrosive (which is the major source of tin in humans). Tin compounds are used in ceramics and to make dyes. Tin is the main component in lead free solder as tin melts easily.

Tin is not used to make coins or jewelry since at winter temperatures the atoms slowly change from a metal crystal arrangement to a cubic crystal arrangement or structure where the tin becomes a dark grey powder.

Tin is an essential trace element in small amounts. Studies where rates were fed a diet with zero tin caused rats to not grow properly. However, very small amounts of tin caused accelerated growth in rats. Too much tin in the rodent studies showed poor growth, reduced feeding efficiency, hearing loss, and hair loss.

Tin has been shown to exhibit a strong effect on the enzyme heme oxygenase, enhancing heme breakdown in the kidneys. There is evidence that tin has cancer prevention properties. Tin deficiencies have been linked to male pattern baldness and deafness in humans. Tin is also known to affect the metabolism of other metals like copper, zinc, and iron.

In animals and humans tin is required but too much can be toxic. When tin is complexed with organic compounds it is easily absorbed. Inorganic compounds of tin are not easily absorbed. Very little of the tin ingested is absorbed (less than 3%) and most of what is absorbed is excreted in our urine.

Tin is found in the bodies of many microorganisms that live in the soil. In soils contaminated with excess tin, it was discovered that some bacteria are immune to the toxic effects of tin, and will concentrate tin up to 7,700 ppm in their tissues. High levels of tin in the soil are toxic to some species of fungi.

Triphenyl-tin is used as a fungicide for agricultural crops. Research in 2002 showed that it suppressed the human body's production of natural killer cells, which are the first line of defense against cancer. This compound also damaged the nervous system of tadpoles and frogs.

Tin fluoride (SnF_2) and tin chloride ($SnCl_2$) are known to inhibit the functions of our liver. Additionally, too much tin will compete with the required nutrient zinc preventing its absorption. Tin is commonly used in dentistry under the name stannous fluoride.

Tin tartrate was found to cause a decrease in the antioxidant glutathione leading to liver damage in animal studies.

Gardening and Landscaping Problems Associated with Tin (Sn)

There is no evidence that tin is required or used by plants, however tin is easily absorbed by plants where it accumulates in the roots and very little is translocated to above ground parts of a plant. The amount of tin in plants varies between 1-300 ppm but 5-10 ppm is the most common. Sedges and mosses tend to be high accumulators of tin.

Whole grains can have 7 ppm and corn 3 ppm of tin. Measurements have shown that sugar beets grown on contaminated soil can have 1,000 ppm of tin.

There is no evidence of toxicity to plants unless there is extremely high levels in the soil.
Sources: coal, coal ash, smelters, mine tailings.