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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 4, 5, and 6 on the Periodic table. See previous newsletters for a list of references and introduction to the Periodic Table.

4) Beryllium (Be) - Beryllium is the first or lightest of the elements known as the "alkaline earths" which include calcium, magnesium, strontium, etc. listed in column two of the periodic table.

It is found in many minerals but most often found in the mineral Beryl which is beryllium aluminum silicate ($Be_3Al_2Si_6O_{18}$) which is a source of this element. It is a metal used in nuclear reactors, aerospace, and electronics.

If we add a few atoms of the element chromium (Cr) to the crystal structure of this mineral we get the gemstones we call emeralds. Change a few other atoms and we get the gemstone aquamarine. We find beryllium in igneous rocks at 2-8 ppm, shale at 3 ppm, and only 0.1 for sandstone or limestone. It accumulates in coal and can often reach 330 ppm with some levels as high as 2,000 ppm in some deposits.

Beryllium is used as a "rock clock" as oxygen in the rocks (or the atmosphere), when exposed to cosmic radiation, changes into beryllium-10, and by measuring the amount of beryllium one can calculate the age of the rock.

Gardening and Landscaping Problems Associated with Beryllium (Be)

Beryllium is found in fresh water at 0.001 ppm and seawater at 0.0000006 ppm. For land plants, it is less than 0.1 ppm and even less in land animals. If the human body has plenty of selenium, then we rid ourselves of excess beryllium, as too much beryllium would disrupt the calcium-magnesium relationships or cause berylliosis in our lungs. If beryllium is in a salt form like beryllium chloride ($BeCl_2$) or beryllium sulfate ($BeSO_4$), it is very soluble in water and toxic to plants.

Notice that beryllium is in the same column on the periodic table as calcium (Ca) and magnesium (Mg), which means it has similar chemical properties. Since it is chemically similar to magnesium and calcium, plants easily absorb beryllium. If there is too much beryllium in our soils, it will substitute for magnesium (Mg) and cause antagonistic interactions with several metabolic process's plants require.

It can also substitute for magnesium in human enzymes and cause them to malfunction. If levels in the soil reach 2-16 ppm it can prevent seed germination, inhibit the uptake of calcium (Ca), magnesium (Mg), and to some degree phosphorous (P) along with degrading some proteins and enzymes. In high amounts, it is toxic to many life forms. However, in very small amounts beryllium has been found to stimulate the growth of certain microbes and plant species.

Sources: coal, very small amounts in granite and basalt rocks

5) Boron (B) - Boron is an element that is known as a "metalloid" as it has properties of both metals and non-metals. Boron is found in igneous rocks at 30 ppm, 96 ppm in clays and 145 ppm in limestone, in seawater at 4,500 ppm and in fresh water 2-150 ppm. Boron is an anion, which means it has a negative electrical charge when ionized.

Boron is not found in nature in a pure form as it oxidizes rapidly. Boron is often found in nature as boric oxide (B_2O_3) or borate salts often formed by evaporating seawater. It is also found in feldspars and micas, which are common minerals in clay soils or as the insoluble mineral tourmaline, a semi-precious gemstone. In tourmaline, the boron is chemically locked up and not in an available form until actions by microbes breaks the molecule apart and release the atoms of boron.

Boron is used in pesticides, cosmetics, and fertilizers. Combine boron with nitrogen and we get cubic nitride crystals that are almost as hard as diamonds and they are more heat resistant, hence, they are commonly used for abrasives in many industries. When boron is combined with iron (Fe) and neodymium (Nd), it forms one of the strongest magnets known.

Boron is found in household products from Silly Putty to Borax cleaning agents (sodium borate). As a result, boron is a major source of pollution in streams as it comes from the sewage sludge from our waste water treatment plants where all these chemicals are dumped and accumulate. Soil contamination with excess boron is now a worldwide problem.

The Carnegie Institute for Science has found that trace amounts of the element Boron (B), is what makes diamonds blue (think of the world-famous Hope Diamond). They also found that these blue diamonds are formed many times deeper in the earth (much hotter and higher pressures) than regular diamonds.

Boron has beneficial effects on bone and joint strength in humans and is essential to promoting strong healthy bones. It is estimated that 75% of the USA population is boron deficient. In humans, boron has an important role in mineral and hormone metabolism, cell membrane function, and enzyme's function. Boron affects osteoporosis, heart trouble, diabetes, and senility.

Its deficient effects are more marked when vitamin D_3 and magnesium (Mg) are also deficient. Studies have shown that it protects men against deadly prostate cancer (it selectively kills prostate cancer cells while leaving healthy cells unharmed) as it lowers PSA (Prostate Specific Antigen), elevated PSA has been found to be causative factor in prostate cancer progression.

Boron has been found to fight inflammation and decrease joint swelling as it inhibits lipoxygenase (LOX) an enzyme that triggers the inflammatory cascade to increase inflammatory leukotrienes.

Most conventionally grown foods do not provide enough boron (Life Extension, November 2015 pp. 33-38). I looked at many artificial fertilizers on the internet and only one contained boron which explains the deficiency in our food supply. Another reason to only use organic fertilizers, remineralizer, and grow your own food.

An article in Life Extension (April 2018) summarizes studies that found boron also helps prevent lung and cervix cancers. Mice fed a boron deficient diet had 63% reduction in osteoblasts which are the bone making cells. Boron was found to help prevent many forms of cancer from getting started. A lack of boron is associated with osteoporosis, poor memory and concentration, weak muscles and ageing skin.

I was reading about a new study on women in Turkey. The study compared women living in areas of Turkey that have boron rich soil to areas that are boron poor. Women living in areas

of Turkey that have boron rich soil did not have a single incident of cervical cancer. "Boron interferes with the life cycle of the human papillomavirus (HPV) which is a contributing factor to 95% of all cervical cancers."

A study by The University of Texas at the MD Anderson Cancer Center found increased boron intake was associated with a lower risk of lung cancer in postmenopausal women whom were taking hormone replacement therapy.

Boron regulates the absorption of calcium, and it is used in making estrogen. A lack of boron leads to increased menopause symptoms in women and a lack of testosterone in men.

The November 2021 issue of Life Extension has a nice summary of the benefits of adequate boron.

Gardening and Landscaping Problems Associated with Boron (B)

Many forms of boron minerals or ions are readily absorbable by plants. Boron is an essential element for microbial and plant growth; however, all the functions and relations are not fully understood. Mycorrhizal plants have a greater need for boron than non-mycorrhizal plants.

A shortage of boron in the soil is associated with increased insect and fungal damage, and stunting in some plant species while other species seem unaffected. Boron deficiency is often associated with the death of the terminal bud, light green coloring, splintering, or cracking of tubers, root tips swollen and discolored, leaves eventually become brittle and may curl with yellow spotting.

An adequate amount of available boron in the soil is a strong disease fighter since it helps the plants immune system and become more resistant to disease. It is associated with the prevention of many plant problems; cracked stems in celery, internal cork in apples, black heart in beets and turnips, yellowing of alfalfa leaves, etc.

Other signs of boron deficiency are; tips of growing plant turn inward and dies, buds become light green, roots are brown in center, flowers do not form, leaves are small crinkled deformed with irregular areas of discoloration. Boron deficiency is most likely to occur on sandy soils, soils low in organic matter and in areas of high rainfall or frequent watering.

This element is involved with carbohydrate transportation, it is required for certain physiological processes such as enzyme and co-enzyme systems. Boron influences plant growth in many ways but they not fully understood. It also helps plants use nitrogen efficiently.

Studies have found that it is associated with the translocation of sugars in plants hence closely related to quality and taste of foods. Boron regulates flowering and fruiting, cell division, salt absorption, hormone movement and pollen germination, carbohydrate metabolism, water use, nitrogen assimilation and other aspects of plant growth.

Boron interacts in the uptake of other nutrients by plants as it influences membrane permeability and cell colloids. This element is associated with energy transformation reactions, carbohydrate transport, blossom retention, and critical for root elongation.

If there are low levels of zinc (Zn) in the soil, some plants absorb boron to toxic levels, especially in the roots. Boron has an antagonistic relation of silicate ions for absorption sites of boron. Too much calcium (lime) will induce boron deficiency in acid soils. Note: Most artificial

fertilizers make the soil too acidic, hence conventional farmers use lime (calcium oxide) to neutralize the acidity. This greatly decreases the nutritional density of our food.

Too much phosphorus (P) ions will decrease boron mobility in the soil and absorption. Uptake and distribution of phosphorous in plants is dependent on the boron concentration in the soil as too much boron prevents the roots from absorbing phosphorous. However, adequate boron assists plants with potassium (K) uptake.

Boron is used as structural element in the cell walls of plants as it strengthens them, but elevated levels of boron hurt citrus plants like oranges and lemons. Using grey-water that has cleaning agents with boron in them can lead to a buildup of this element in the soil.

Olives will not set fruit if boron levels are too low, and plants grown in soils with insufficient levels of boron are more susceptible to insects and disease. Some believe that boron may function as a natural insecticide since boric acid is toxic to many insects. Some plants like hyacinths require boron to produce their fragrance which contains a boron compound.

However, excess boron in the soil restricts growth, causes sickly green color often mistaken for nitrogen deficiency, associated with root deterioration and poor yields.

One of the problems with using artificial fertilizers is that there is a very narrow range of boron in the soil that decides whether it is toxic or beneficial. Water-soluble artificial fertilizers if they even contain boron, just dump the boron into the soil even if it is not needed causing toxicity problems.

Watering with the affluent from septic systems can also be a source of excess boron in the soils as with grey-water mentioned above.

Food sources are apples, plums, grapes, avocados, most vegetables, nuts, and legumes are our major food sources of boron (if it is in the soil in sufficient quantities for plants to absorb). Prunes, raisins, almonds, hazelnuts, dates are other sources.

Sources:

Sedimentary deposits of borate salts, in feldspars and micas, which are common minerals in some clay soils, igneous rock sands like granite and basalt, remineralizer.

6) Carbon (C) - "Carbon stands supreme as having the chemical properties on which all life depends", John Emsley.

Carbon is found in many forms, from pencil lead to the gemstones we call diamonds. Carbon is the main component of coal and petroleum hydrocarbons that our society depends on for energy. It is also a major component of natural gas in the form of methane (CH_4).

Carbon can be found in igneous rocks at 200 ppm, shales at 15,300 ppm, sandstones at 13,800 ppm, and limestones at 113,500 ppm. In marine plants, carbon increases to 345,000 ppm and in land plants to 454,000 ppm.

When carbon is combined with oxygen (O_2), it forms carbon dioxide (CO_2) which is directly linked to global warming. When carbon dioxide freezes, it becomes dry ice and if dissolved in rainwater it forms carbonic acid with a pH of 5.7

Carbon is the element most used by plants as between 45-56% of a plant's compounds are structured with carbon. Carbon is the basic building block for all organic materials and the key to life, as we know it.

Carbon is frequently referred to as the energy of the soil. For example, when we burn wood in our fireplace, energy is released in the form of heat and light. The carbon in the wood is combined chemically with oxygen (O_2) in the air releasing energy. Alternatively, when carbon in gasoline is combined chemically with oxygen (O_2) in the air releasing energy that powers our cars. Hence, the carbon in organic matter in the soil provides the energy to grow soil life from microbes to earthworms, release nutrients from rocks and minerals, create soil structure, etc.

Gardening and Landscaping Problems Associated with Carbon (C)

If we look at the major components of most terrestrial plants, they can be broken down into glucose, cellulose, lignin, and some proteins. The amount of these compounds varies between species, for example a tree will have more lignin than an annual flower. Additionally, all plants have water (H_2O) in their cells, roots and stems that are not part of the plant. If the water is removed and we look at what is left they are primarily molecules made of carbon chains. A few examples are:

Glucose $C_6H_{12}O_6$ - has six carbon atoms as its base units

Cellulose $(C_6H_{10}O_5)_n$ - has six carbon atoms as its base units

Lignin $(C_{32}H_{34}O_{11})_{n\,-}$ - has 32 carbon atoms as its base units

Proteins are composed of amino acids that all have carbon as their base unit.

We can look at the vascular tissue, the cambium layers, and the bark of the plant, all of which are composed of molecules based on chains of carbon atoms.

Typically, for trees we see the following breakdown: 50% Carbon, 42% Oxygen, 6% Hydrogen, 1% Nitrogen, and 1% other.

When we look at *all the atoms* that compose a plant or tree, carbon is the most common element. As mentioned, carbon in decaying organic matter is the energy source for microbes and other soil life, carbon is the base unit for humus that is so critical for good soil health. Plants can get carbon from the air via photosynthesis or be absorbed via their roots. Note that the character of the nitrogen source governs carbon availability and carbon becomes deficient if too much nitrogen is available (like we get from artificial fertilizers).

Researchers have found that healthy, fertile soils, with low insect, disease and weed pressure have 30 carbon atoms for every nitrogen atom, what is known as a thirty to one ratio (30:1). This ratio is common in natures from microbes, to earthworms, to birds and mammals including mankind.

Sources:

compost, native mulches, Leonardite, humates, and coal.