NATURE'S WAY RESOURCES
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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. See previous newsletters (9/17/21 and 9/24/21) for a list of references and introduction to the Periodic Table.

I had a customer tell me yesterday how much better his vegetables taste after using -re-mineralizer and getting the trace elements back into the soil. Since spring is just a few weeks away and time to start thinking about our spring vegetable gardens, hence we are going to pick up the pace of looking at the remaining elements.

Today we look at elements 33-39 which are arsenic, selenium, bromine, krypton, rubidium, strontium, and Yttrium.

33) **Arsenic (As)** - Arsenic is a metalloid that has two common forms, grey or alpha-arsenic which is metallic, brittle, tarnishes, burns in oxygen and resists attack by water, acids and alkalis. The second form is yellow arsenic or beta-arsenic, which is non-metallic.

Arsenic is found in igneous rocks at 1-8 ppm, shale at 13 ppm, sandstone and limestone at 1 ppm, soils at 6 ppm, and there is hardly any in fresh or salt water at 0.003-0.004 ppm. However, in marine plants arsenic can reach 30 ppm but only 0.02 ppm in land plants.

It is an essential trace element for animals and humans, and it is essential for the survivability of newborn and neonatal growth.

In nature, arsenic is rarely found in a pure or uncombined form. The most common minerals are red realgar (As_4S_4), yellow orpiment (As_2S_3), silvery arsenopyrite (FeAsS), and iron grey enarite (Cu_2AsS_4).

Most arsenic production occurs as a byproduct of refining other metals such as copper, iron, or lead. Arsenic is found combined in nature with many elements to form a range of minerals as it has electrical oxidation states that range from -3 to +5.

Arsenic compounds were used to make bright yellow or green paint. Other uses include rat poison, taxidermy, weed control, wood preservative, microchips, liquid crystal displays, semi-conductors, batteries, glass, televisions, etc.

One of the first arsenic compounds used was "Paris Green" (copper acetoarsenite) and is one of the few chemicals that were used as both a rat poison and a paint pigment. Paris green was once used to kill rats in Parisian sewers hence the common name. In Britain, this chemical was used to make wall paper that when exposed to humidity, molds would convert the arsenic to gas forms that would make people sick (arsenic in the gas form AsH_3 where over 5 ppm is harmful). The doctors of the day would send the people to the beach and the illness would clear up. Hence being at the beach became associated with healing.

Arsenic stimulates growth in chickens and other poultry, and in a few other animals like pigs. In chickens in combination with choline, it prevents 100% of perosis (slipped tendon disease) and causes them to grow faster. Over **900 tons** of arsenic is added to chicken feed each year for the last 30 years, when the manure from these animals are used in fertilizers and applied to fields to grow crops it breaks down into inorganic arsenic, which is absorbed by the crops and enters the food supply causing many health problems including cancer. This practice is being phased out but it will take decades to undo all the damage and contamination of our agricultural fields.

Although rare, arsenic deficiency in humans, results in carpal tunnel syndrome and other repetitive motions type degeneration.

Arsenic can also have a tonic effect by activating enzymes. The arsenite ion $(AsO_3)^{-2}$ allows oxidation to proceed at an increased rate hence it stimulates metabolism and formation of red blood cells. Arsenic is found in all body tissues including bone, hair, nails, etc. If you noticed above arsenic regularly bonds with sulfur forming several minerals. Hence, arsenic bonds to the sulfur elements in keratin a main component of hair, which is why a hair test reveals one's exposure to arsenic.

Arsenic compounds were used as medicines from the Mediterranean to China. Arsenic was the first cure for the disease syphilis in the form arsphenamine and sold under the name Salvarsan. Many of the famous spring waters with healing properties contain dissolved arsenic (Vichy-2 ppm, Zam Zam holy water from Kabba near Mecca has even more).

Pine needles once were crushed and steeped as a tea in boiling water to deliver enough arsenic to prevent mis-carriage.

Low levels of arsenic help fight cancer and high levels have been found to cause cancer. Arsenic has the property "hormesis" which means small amounts are beneficial and large amounts are toxic (poisonous). Animals fed an arsenic free diet had stunted growth, as it is used in the metabolism of the essential amino acid arginine.

Arsenic was often sold in Europe on the black market as "succession powders" as it was used to kill Kings to Popes as only a dose of 200 mg is fatal. A dangerous form of arsenic is "White arsenic" (As_2O_3) that was originally just called trioxide. Several forms of arsenic were used as chemical weapons in World War 1.

Excess arsenic has been linked to numerous detrimental health problems; diabetes, heart disease, cardiovascular issues, respiratory distress, impaired neurological development and depression.

Historically 80% of all produced arsenic has been used in the manufacture of pesticides, soil sterilant, and herbicides used in agriculture. As a result, many of our agricultural soils have high levels of arsenic.

Arsenic in the soil can switch between two different forms depending on soil conditions, in soggy flooded fields, we get arsenite, or after it dries out a little it becomes arsenate. Arsenic easily changes from any of its electrical states to a different one.

Symptoms of mild arsenic poisoning are alopecia, constipation, confusion, delayed healing, dermatitis, diarrhea, edema, fatigue, seizures, numbness and weakness, etc.

Arsenic is often added to artificial fertilizers as a disposal method for hazardous waste as it is very profitable for fertilizer manufactures. Note: It is illegal to add toxic waste to organic fertilizers.

A good book on why and how this happens is Fateful Harvest by Duff Wilson, Harper Collins Publisher, ISBN 0-06-019369-7, It is a history of how hazardous waste is disposed of in synthetic (artificial) fertilizers and ends up contaminating the food supply. Wilson was an investigative reporter for the Seattle Times Newspaper and published a series of articles in 1997-1999 on this dangerous method of disposing toxic wastes.

Farmers in Washington State used these heavy metal toxic fertilizers to grow potatoes, which are then used to make French fries by the fast-food industry.

Researchers at the University of Oklahoma have found that in Bolivia farmers use wastewater from mining to irrigate their fields of potatoes and the level of arsenic is 9-71 times higher than

the safe level. Note: Heavy metals like arsenic have been linked to autism and ADD, and ADHD. Recently, arsenic has been linked to increased risk of type-2 diabetes (Environmental Health Perspectives 04/2018).

Additionally, long term exposure to arsenic can lead to lung, skin and bladder cancer.

Agricultural soils of Oklahoma and Texas are contaminated with arsenic with levels as high as 830 ppm from years of pesticide and herbicide application. Researchers have found that fields treated with arsenic trioxide pesticides during the 1950's are now leaching into groundwater and surrounding soils.

Some animals have high levels of arsenic; oysters at 4 ppm, mussels at 120 ppm, and prawns at 174 ppm. However, it does not hurt those that eat them as the arsenic is in an organic form known as arsenobetaine, which is easily absorbed and excreted in our urine.

There is evidence that B- vitamins can help the body break down arsenic into a more readily excretable form (Environmental Health Perspectives 04/2018).

Gardening and Landscaping Problems Associated with Arsenic (As)

Arsenic over 2 ppm by dry weight will kill most plants; hence arsenic is a common ingredient in many herbicides.

Note: Many artificial fertilizers can have 188 ppm of arsenic in them in various chemical forms.

Rice as a crop has higher levels of arsenic than other foods as rice absorbs arsenic from both soil and water and in the inorganic form. However, rice plants have enzymes that can convert arsenic into a non-toxic form and return it to the soil, leaving less in the plant to harm humans.

The plants transform arsenate into arsenite and push the molecules back into the soil (Plant Physiology 11/16).

A study on soil temperature and arsenic absorption in rice plants recently published in the journal Agricultural and Environmental Letters found that as soils temperatures warmed as projected by global warming, arsenic concentration increased in root tissue, straw tissue, and husks. The amount in the grain did not change as much, however it illustrates that warming temperatures will change how we grow plants.

Arsenic is phytotoxic to tomato plants at concentrations of 2 ppm where it accumulates in the roots. The level in all plants increases with increasing concentration in the soil.

Symptoms of too much arsenic in our soil are wilting; violet coloration of leaves, root discoloration, cell plasmolysis, and the most common is slow growth.

The flowers of *Linanthus parviflorus* (a member of the pink family) turns from white to red when exposed to soils with heavy metals.

Some plants thrive on arsenic such as the Chinese Ladder or Brake Fern (*Pteris vittata)* which can have over 2% (2,000 ppm) in its tissues. The Douglas fir can absorb high levels of arsenic. Sarghina (*Corrigiola telephiifolia*) has been measured at 2,110 ppm. Other hyper-accumulators of arsenic are Huisache (*Acacia farnesiana*) and Smooth Mesquites (*Prosopis laevigata*)

Arsenic in the form of arsenic acid (H_3AsO_4), was used as a defoliant for decades especially for cotton. Hence, after many years of application there is a large accumulation of arsenic in the soil. Even though arsenic is no longer used, cotton meal and cotton burr compost may still have high levels of arsenic from being grown in soils where the arsenic accumulated over decades of use.

A major source of arsenic in landscaping is from CCA treated wood (Copper, Chromium, and Arsenic). These elements slowly leach into the soil over time as the wood decomposes.

Some garden soils have been found to have 15,000 ppm of arsenic!

Sources: poultry manure, some greensands, artificial fertilizers, CCA treated wood, some seafood, some cotton burr products (meal and compost), sewage sludge (Biosolids and composted Biosolids), coal ash, pesticides and herbicides.

34) **Selenium (Se)** - In general selenium is found in igneous rocks at 0.05 ppm, shale at 0.6 ppm, sandstone and limestone at 0.05-0.08 ppm, fresh water at 0.02 ppm, sea water at 0.00009 ppm, and soils at 0.2 ppm. However, selenium is not evenly distributed hence much higher levels can occur in some areas while some areas of the earth have none.

Marine plants can have 0.8 ppm, land plants can have 0.2 ppm, and land animals at 1.7 ppm. Selenium has an electrical oxidation state that ranges from -2 to +6, which allows it to combine with many elements creating over 50 known minerals.

The lowest amounts of selenium occur in light sandy soils. Clay soils have the ability to absorb selenium as do organic soils. Soil microbes play an important part in making selenium available for plants to absorb.

Selenium is another element that has the property "hormesis" which means small amounts are beneficial and large amounts are bad. It was first discovered that selenium was critical to human health in 1975 by a researcher in Galveston, Texas.

Selenium was first used in pottery to give a red glaze and later as a pigment for dyes to get an orange and maroon color. Selenium was used in many solid-state electronics before silicon and germanium semi-conductors became available.

Selenium photocells were used in photographer's light meters and Xerographic photocopiers and laser printers. They use selenium in a form that when dark it acts as an insulator but when exposed to light it becomes a conductor of electricity.

Selenium sulfide (Se_3S_5) is a common ingredient in dandruff shampoos.

Selenium is an efficient anti-oxidant (anti-peroxident) and is found in the molecule glutathione peroxidase enzyme system. It prevents body fats from going rancid.

Selenium is an essential micronutrient that comes from our diet. It is estimated that over one billion people in the world are selenium deficient.

Higher levels of selenium in the blood are associated with a decreased risk of developing liver cancer (American Journal of Clinical Nutrition, International Agency for Research on Cancer, 2016).

Selenium has also been found to reduce the incidence of lung, colorectal and prostate cancer, total cancer incidence, and cancer mortality. Selenium enriched yeast (fungi) has been found to be the most effective delivery method in some cancer studies.

Many areas of the United States (Texas, southwest, lower southeast, and northwestern mountain states) have very selenium deficient soils, hence plants grown in the area are also selenium deficient. Medical studies have found that America's "Stroke Belt" runs right across America where selenium content in soils is low.

Selenium is important in protecting humans against chronic degenerative diseases, as it is required in the production of powerful antioxidants such as vitamin E and glutathione peroxidase (an enzyme that converts hydrogen peroxide into water).

A study found that when older people who took a combination of CoQ10 and selenium daily for four years, they suffered far 50% fewer heart attacks.

The amount of beta-carotene and vitamins C and E contained in herbs (mints), are linked to the amount of selenium in soil. The effectiveness of anti-oxidants in our bodies have also been linked to the presence of this element. Animals and humans obtain selenium from the foods they eat, however, if it is not in the soil then it will not be in the food.

Selenium has also been found to increase the bioavailability of iron and zinc already present in plants.

A lack of the mineral selenium leads to muscular dystrophy, cancer, heart disease, cirrhosis of the liver, and cataracts along with cardiomyopathy and joint problems.

Selenium is a co-factor for at least 25 enzymes that cannot function without it. It helps protect the body from DNA damage, and it helps eliminate toxic heavy metals from the body. As long as the body has adequate levels of selenium then the body also rids itself of excess beryllium. Selenium helps protect the body against toxic metal poisoning as it can block heavy metal bioavailability and reduce the toxicity.

Mercury can cause a depletion of selenium in our bodies. Selenium binds readily with mercury into a compound that can be removed from the body as a waste product. Methyl mercury blocks selenium related enzymes from functioning correctly. Note: Methyl mercury is found in fish.

Studies show that those with lower selenium levels have much higher incidence of all forms of cancer. Studies of colon cancer survivors with highest levels of selenium were found to be the

least likely for reoccurrence. Research has shown that selenium contributes to anti-oxidant pathways which stimulate apoptosis (cell death) in human cancer cells. A lack of selenium (Se) allows viruses to replicate more quickly. Higher selenium blood levels are associated with better breast cancer survival rates.

The body cannot absorb selenium very well in some forms like L-selenomethionine, however one of the best forms for the human body to absorb selenium is from selenium enriched yeasts (fungi).

Cardio-myopathy (heart attacks), white muscle disease in animals, liver spots and age spots are all linked to selenium deficiency. Low levels of selenium have been associated with pancreatic cancer. As we get older, we tend to lose the ability to absorb selenium. As men's level of selenium decrease, their sperm count and quality does also.

Recent studies have linked low levels of selenium to cognitive decline in the elderly. Mothers whom have adequate selenium levels tend to have children with better brain function. Children that have adequate selenium levels tend to perform better on all cognitive tests.

An animal study published in the journal Cell has found that selenium helps prevents neurons from dying, illustrating the element's role in mitigating cell death and preventing dementia. Selenium is used in an enzyme called GPX4, it was found essential to life. Another study in the Journal of Nutrition, found that adequate selenium levels helped prevent the onset of depressive symptoms and negative mood.

Selenium has been found to help our immune system fight viral pathways, reducing symptoms of viral infections such as SARS, coxsackievirus, Ebola, and HIV-1.

A study in the American Journal of Epidemiology showed that selenium intake reduced brain loss associated with aging.

There is also a strong link to osteoporosis as higher rates of problems are associated with low selenium levels. The human thyroid gland has the highest level of selenium.

Some of the health problems and diseases that have been linked to a selenium deficiency are:

HIV (Aids)
Anemia (RBC fragility)
Age spots and Liver spots
Asthma
Fatigue
Fertility issues
Muscular weakness
Myalgia
Scoliosis
Muscular Dystrophy
Cystic Fibrosis
Cardiomyopahy
Multiple Sclerosis (associated with mercury poisoning)
Heart palpitations
Irregular heartbeat
Liver cirrhosis
Pancreatic atrophy
Lou Gering's Disease (also with mercury poisoning)
Alzheimer's disease (with high vegetable oil consumption)
Infertility, Low birth weight babies
High infant mortality
Sudden Infant Death Syndrome (SIDS)'
Cancer
Sickle Cell Anemia

A study in Nutritional Health and Ageing on elderly people in Italy found that having a high selenium level was associated with a 29% lower risk of death from all causes.

As one Doctor stated, "a high intake of vegetable oils, cooking oils, and margarine concurrent with a selenium deficiency is a quick way to a heart attack".

Most of the selenium we absorb, 50-80% is excreted in our urine. It is not common but excess selenium can cause garlic breath and is the first sign of selenium poisoning.

Selenium in the form hydrogen selenide gas (H_2Se) is extremely toxic.

A few sources of selenium are sodium selenite a simple chemical salt (Na_2SeO_3), Selenium-methyl L-selenocysteine, and high selenium brewer's yeast. Brazil nuts are a good source of selenium. Pasture raised eggs, shellfish, organ meats, wild caught Alaskan salmon, tuna, halibut, sardines, shrimp and many seeds. Other sources include free-range chickens, turkey and pork, fish, free range organic eggs, shellfish, liver from grass fed beef or lamb, and coconuts.

Gardening and Landscaping Problems Associated with Selenium (Se)

Some plants require selenium while other does not. Members of the *Astragalus* family tend to colonize selenium rich soil, as they require it. Some members are known as "Locoweed' due to the high levels of selenium they absorb and its effects on animals whom eat it. Its presence often indicates soils with high selenium levels.

Rhizobium bacteria and root exudates stimulate the oxidation (adds an extra oxygen atom to the molecule) of SeO_3 to SeO_4 which increases the availability of selenium to plants.

Some studies have found that adequate selenium in the soil stimulates the growth of grasses and other plants, while too much can be toxic.

Brassica plants have a high ability to absorb selenium from the soil, as do many mushrooms and ferns that can absorb selenium in larger amounts. The mushroom *Albatrellus pes-caprae* that is a popular food in Italy can have 3,700 ppm of selenium.

Sources: some coal ash (10-6,000 ppm), sodium selenite, basalt and granite sands, greensand, re-mineralizer

35) **Bromine (Br)** - The name comes from the Greek word *bromos* which means stench. We use the name Bromine when this element exists as the molecule Br_2 (two atoms of Bromine bonded to each other) and Bromide when a bromine atom is combined with something else (ex. potassium bromide, KBr). Bromine is very reactive and dangerous while bromide is relatively safe.

Bromine is in group 17 on the periodic table and is one of the halogens that is related to iodine, and along with iodine it is in the same column on the periodic table as chlorine and fluorine.

Bromine is found in igneous rocks at 3-5 ppm, shale at 4 ppm, sandstone at 1 ppm, in limestone and fresh water at 0.2 ppm, seawater at 65 ppm and in most soils around 5 ppm while coal can have 9-160 ppm. Marine plants have 740 ppm and land plants about 15 ppm. Marine animals have 60-1,000 ppm of bromine while land animals only have 6 ppm.

Bromine is one of only two elements that is a liquid at room temperature. Bromine is very corrosive and in its gas form, attacks the eyes and lungs if breathed. Only 100 mg is a fatal

dose for humans while bromide requires over 3,000 mg to promote a response and much more before it becomes toxic.

Bromine is found in all living creatures from microbes to humans. Small amounts of bromine have been found in many natural springs associated with healing properties.

Bromine, its salts, and other compounds are used for dyes, disinfection, pharmaceuticals, agricultural chemicals, and fire extinguishers. The natural dye used to color the royal purple robes and togas worn during biblical times contained bromine atoms.

Bromide was once used to make flame-retardants but as a persistent chemical with hormone disrupting properties in the environment, it has been phased out. Bromine is used in pesticides, plastics, bakery goods, soda medications, hot tub, and swimming pool treatments. In all of these uses, the bromide compounds are hormone disruptors.

For years methyl bromide (bromomethane, CH_3Br) was used as a soil fumigant as it killed almost all soil life from nematodes to bacteria and fungi. This dangerous chemical was phased out since it contributed to the destruction of the ozone layer that protects all life on Earth.

Another former use for bromine was ethylene dibromide combined with lead, which was used as an anti-knock ingredient in gasoline.

It was found that the process of ozonizing water to sterilize it, coverts any bromide in the water to bromate (BrO_3^-) which is a carcinogen. Brominated vegetable oil (BVO) is added to citrus drinks and many soft drinks to help suspend the flavorings.

Bromine is used in helping cells in multi cellular animals stick together. They stabilize cellular support structures called basement membranes. Insect studies found those insects low in bromine that 80% of the eggs failed to live. June 5, 2014 Journal Cell, Science News, July 12, 2004, p. 15.

Other studies have shown that mammals require bromine to form brominated amino acids that are used in various metabolic processes.

Bromine compounds are very common in our environment and problems occur due to its similarity with iodine. Iodine is crucial for proper thyroid function. With dropping levels of iodine in our food supply and increasing levels of bromine compounds, the body is replacing iodine with bromine preventing our thyroids from functioning properly.

One study found that 20% of all hospital admissions for "acute paranoid schizophrenia" were a result of consuming bromine containing products. Too much bromine can cause skin rashes, severe acne, loss of appetite, abdominal pain, fatigue, metallic taste, and cardiac arrhythmias.

For more information on health issues:
http://articles.mercola.com/sites/articles/archive/2009/09/05/another-poison-hiding-in-your-environment.aspx

Gardening and Landscaping Problems Associated with Selenium (Se)

When greenhouses are fumigated with methyl bromide plants can hyper-accumulate this element. Greenhouse grown lettuce has been found with levels of bromine up to 0.1 % of their weight.

Bromine is found in all plant tissues; however, we do not know if it is essential to plant growth and health. Marine plants can concentrate bromine to over 1,000 times of that in seawater.

Some plants are sensitive to bromine (potatoes, spinach, sugar beets, onions, carnations, and chrysanthemum). Other plants can accumulate bromine to over 2,000 ppm without harm (carrots, tobacco, tomato, celery, and melons).

Since bromine is chemically similar to chlorine, it is believed that it can substitute for some of the chlorine requirements of plants.

Symptoms of bromine toxicity resemble excess salt effects, with chlorosis followed by leaf tip necrosis as the most common symptoms.

Sources: Igneous rock dusts from basalt and granite, seaweeds, re-mineralizer

36) **Krypton (Kr)** - Krypton is another of the "Noble" gases as it refuses to bond with other elements. In nature, krypton is a clear odorless gas. Krypton is famous for its role in the Superman comics and movies as the substance kryptonite. In reality, krypton is virtually harmless to humans and may be an essential element.

Krypton is found in igneous rocks at 0.0001 ppm and seawater at 0.0025 ppm. Most of our krypton comes from the atmosphere where it is extremely rare and occurs at 0.00011 % (1.1 ppm).

Krypton is produced by the radioactive decay of uranium in nuclear reactors.

It is used in high quality tungsten light bulbs from flashlights to incandescent lights. When energized, krypton glows bluish white making it useful for photoflashes and signage.

The isotope krypton-83 is used in MRI imaging of our lungs. In one of the rare exceptions krypton will combine with fluorine to form (KrF_2) at temperatures below -22° F where it is used to make a krypton-fluoride laser.

In science at one time, the wavelength of an emission line of krypton was used to define the length of a meter.

There have been a couple studies that found that it is associated with the amino acid isoleucine, but the relevance is unknown.

Gardening and Landscaping Problems Associated with Krypton (Kr)

None known, good or bad

Sources: atmosphere

37) **Rubidium (Rb)** - The name comes from the Latin word *rubidius* which means the deepest red (ruby). No rubidium minerals are known; however, it accumulates in lepidolite (a lithium bearing mineral) where it can be 1.5% of the mineral. It is found in other minerals but again uncombined chemically. Some brines have 6 ppm of rubidium.

Rubidium is found in igneous rocks at 90 ppm, shale at 140 ppm, sandstone at 60 ppm, and limestone at 3 ppm. Very little is found in fresh or seawater. In soils in can reach 100 ppm, marine plants at 7.4 ppm, land plants at 20 ppm, and in marine, or land animals at 17-20 ppm.

Rubidium is a very soft metal with a silvery-white luster, it will ignite if exposed to air, and it reacts violently with water.

In humans, the highest levels occur in the liver and muscles with very little in our bones. Rubidium can replace the electrolyte function of potassium in many species from bacteria and fungi to algae and invertebrates.

Small amounts of rubidium are used in semi-conductors, a few electronic and chemical applications.

Rubidium has no direct biologic role. However, it has a small stimulatory effect on metabolism. If you note that rubidium is directly below potassium (K) on the periodic table, hence it has chemical properties that are similar and may substitute for potassium in many processes.

Rubidium is easily absorbed in our digestive system where it is found all over the body except in bones and teeth and any excess is excreted in our urine.

Gardening and Landscaping Problems Associated with Rubidium (Rb)

Plants absorb rubidium very easily since it is chemically similar to potassium.

Sugar beets if grown in a potassium deficient soil will respond to rubidium as a fertilizer. Soya beans have 220 ppm, grass has 130 ppm, apples have 50 ppm rubidium, while sweet corn only has 3 ppm. Other plants from tea and coffee also contain rubidium.

In high concentrations, it can be toxic to plants where symptoms are dark green leaves, wilting and stunted foliage, and short brown roots.

Sources: sewage sludge (100 ppm)

38) **Strontium (S**r) - Strontium is a metal in group 2 on the periodic table. It has a silvery appearance that turns yellowish after oxidation. It is a soft metal that will burn in air and reacts with water. Strontium does not occur in nature as a free element but only in a combined form with other elements forming several minerals.

This element is found in igneous rocks at 375 ppm, shale at 300 ppm, sandstone at 20 ppm, and limestone at 610 ppm. In fresh water at 0.08 ppm and seawater 8.1 ppm, marine plants at

260-1,400 ppm, soils at 300 ppm, land plants at 26 ppm, marine animals at 20-500 ppm and land animals at 14 ppm with the highest levels in mammal bones.

Strontium occurs in two common minerals, celestite or strontium sulfate ($SrSO_4$) and strontianite or strontium carbonate ($SrCO_3$).

Strontium aluminates are used to make paint that glow in the dark. Strontium is used in many common products from toothpastes to televisions, ceramics, and glass manufacture. Strontium nitrate $Sr(NO_3)_2$ is used in flares and fireworks to give a strong red color.

A radioactive form or isotope of strontium (strontium-90) that does not occur in nature is formed in nuclear explosions and later is in the fall out. The radioactive isotope is known to cause bone tumors and leukemia.

Strontium has a +2 electrical or oxidation state, which is the same as calcium; hence, it is chemically similar to calcium and used in making our bones and mimics calcium in biological systems. It is required by mammals to make strong bones. As we get older, the body cannot utilize strontium as easily, which leads to weaker bones.

Deficiencies of strontium are associated with some types of calcium (Ca) and boron (B) resistant osteoporosis and arthritis. A study published in the Journal Ageing has found that women whom ingested 450 mg strontium (strontium citrate) daily along with melatonin, vitamin D-3, and vitamin K-2 had a significant increase in bone density after one year.

One study by the United States Geological Survey found that 2.3 million Americans are exposed to high levels of strontium in their drinking water where excess levels can harm bone health. High concentrations can stunt bone growth in children and cause the disease called rickets.

Gardening and Landscaping Problems Associated with Strontium (Sr)

Since strontium is chemically similar to calcium (Ca) plants readily absorb it, where it tends to accumulate in the roots.

Plants like cereal grains tend to absorb the least strontium while in alfalfa even though rare, levels up to 1,500 ppm have been measured. It is easily absorbed by tobacco plants and some mosses.

If the ratio of strontium to calcium (Ca:Sr) is less than 8, then strontium phytotoxicity may occur. Phosphorite deposits where we get phosphorus for artificial fertilizers often have over 2,000 ppm of strontium thus many artificial fertilizers have elevated levels of strontium and repeated use of these fertilizers leads to toxicity problems.

Proper levels of calcium (Ca) and magnesium (Mg) in the soil prevent excess strontium from being absorbed.

Heavy loam soils can accumulate up to 3,100 ppm of strontium while sandy soils hold very little. In Texas the carbonate aquifers like the Edwards-Trinity may have high levels of strontium. Reverse osmosis water filters are very effective at removing strontium from drinking water.

Sources: burning of coal, sulfur mining, artificial fertilizers, some manures, some dolomite formations

39) **Yttrium (Y)** - One writer describes Yttrium as a "hippy" element. Yttrium is a silvery metal of group 3 of the periodic table and behaves chemically similarly to the lanthanide group. It is often classified as a rare earth element (even though it is twice as abundant as lead).

Yttrium is found in igneous rocks at 33 ppm, shale at 18 ppm, sandstone at 9 ppm, and limestone at 4.3 ppm. Very little is found in seawater (0.0003 ppm) however in soils it is found at an average of 50 ppm with a range of 2-100 ppm. In marine mammals, it occurs at 0.1-0.2 ppm and land animals at 0.04 ppm. Yttrium is found in mammalian bone, teeth, and liver.

Yttrium has an electrical or oxidation state +3 and never occurs alone in nature. However, it is often found in association with many minerals like oxides, carbonates, silicates, and phosphates.

When yttrium is combined with barium and copper into an oxide ($YBa_2Cu_3O_7$), it becomes a superconductor of electricity when cooled to very cold temperatures. When yttrium is combined with aluminum and silicates, we get garnet crystals which is used to produce powerful lasers and it can also make very hard diamond-like gemstones.

It is used in color television and computer monitors, luminescence and semi-conductor devices. It is used in ceramics and glass manufacturing and is used as a catalyst in the production of some plastics.

Exposure to some yttrium compounds can cause lung disease in humans. Excess yttrium may cause some toxicity issues from enzyme inhibition to indirect effects by binding to cofactors, vitamins, and substrates. In general, yttrium salts, are considered mildly toxic if they are soluble and non-toxic if they are insoluble.

For years, it was thought that Yttrium had no biological role in humans even though it is found in every living organism (sometimes in high amounts). However, recent research is suggesting that it does play a role.

It has been found that high levels of aluminum suppress the body's ability to utilize yttrium and boron, and can trigger the suppression of beneficial probiotic organisms.

Yttrium also enhances normal cell growth and doubles the lifespan of laboratory animals. In rodent studies, 14% of the ingested Yttrium can be detected in the newborn mice. Yttrium has been detected in nucleic acids and even human breast milk contains 4 ppm of Yttrium.

A deficiency of yttrium has been linked to several metabolic diseases (Lou Gehrig's, Alzheimer's, multiple sclerosis, and Parkinson's disease). In the absence of certain trace elements, DNA will make use of substitutes. One doctor has found that if there is an Yttrium deficiency, which is used at junction of a gene and DNA molecule, without Yttrium, aluminum is used which is a different size atom that results in misalignment of the gene and a genetic mutation due to nutrition occurs.

Gardening and Landscaping Problems Associated with Yttrium (Y)

Most plants have about 0.6 ppm of yttrium. However, many *edible plants* may have 20-100 ppm with cabbage at the higher end of the range.

The seeds of woody plants can have 700 ppm of yttrium. Nuts are seeds and are some of the healthiest foods we can eat; I wonder if this is a coincidence?

Mosses and lichens tend to accumulate more yttrium (20-100 ppm) than other species, which suggest that a lot of their accumulation is from atmospheric deposition.

Sources: NPK artificial fertilizers at 14 ppm, Phosphorous (P) fertilizers at 114 ppm, sewage sludge 11 ppm, fly ash from burning coal at 44 ppm, re-mineralizer.