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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.

Continuing to pick up the pace to get ready for spring, today we look at elements 56-65 which are barium, lanthanum, cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, and terbium. Unless one is a scientist you have most likely never heard of some of them. However new research has shown that many of them are linked to longer lifespans in mammals including humans.

56) **Barium (Ba)** - Barium is a soft silvery-white metal found all over the earth. In igneous rocks, it may range from 0.5-1,200 ppm with an average of 425 ppm and in sedimentary rock 50-800 ppm, thus barium is common in soils from 100-3,000 ppm. Barium gets its name from the Greek *barys*, which means heavy. This derives from minerals that have barium in them and they are heavy.

Barium in soils average 500 ppm where it is in mobile forms. However, it easily precipitates as sulfates and carbonates and will be absorbed by clays, oxides, and hydroxides. Coals may have 75-330 ppm of barium.

Barium is an alkali metal in group 2 of the periodic table of elements, it reacts quickly with oxygen in the air, making it useless for many applications. In vacuum tubes, a piece of barium was included to react with any trace amounts of leftover oxygen, nitrogen, or water to prevent these from interfering with the function of the tube.

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One of the benefits of barium is the density of slurries containing barium compounds. An example is the drilling mud (barium sulfate, BaSO_4) which is used in oil well drilling to prevent blow-outs (90% of all usage of barium). Barium is also used in the manufacture of ceramics, bricks, tile, and glasses. A compound of barium composed of barium, yttrium, carbon and oxygen is a superconductor. Barium nitrate is used to produce a green color in fireworks. The rare mineral below, which is a barium-titanium-silicate ($\text{BaTiSi}_3\text{O}_9$) that has a translucent blue color, which can be cut and turned into a gemstone.



Barium is found concentrated in phosphate bearing rocks, thus artificial fertilizers often have high barium levels. Barium most often occurs with a +2 electrical or valence state. Its common



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minerals are barium sulfate or Barite (BaSO_4), barium carbonate called Witherite (BaCO_3), and Hollandite ($\text{Ba}_2\text{Mn}_8\text{O}_{16}$).

Until recently, barium was considered to have no biological role, but today, it is considered essential for our health.

Barium is mainly found in the bones and teeth of humans. One report stated that the AIDs virus loves barium and an excess may help it reproduce. Barium sulfate due to its density is often ingested, to enhance medical imaging of soft tissue in our stomachs and intestines.

One use for barium is in animal studies, researchers found that mother orangutans transfer barium from their own skeletons to their babies while they are nursing. This forms layers in the babies' teeth that can identify how many years the babies have nursed (orangutans often do not wean until 8 years of age). Science News, June 2017

Gardening and Landscaping Problems Associated with Barium (Ba)

It is generally believed that barium plays no role in the metabolism of plants. However, plants, especially in acidic soils, easily absorb barium with greater absorption at lower pH levels. Most plants have 2-14 ppm of barium in their tissues with higher levels found in dryer climates. Wheat has 3.2 ppm, cereal grains 5.5 ppm, carrots 13 ppm, lettuce 9 ppm, beans 8 ppm, tomatoes 2.1 ppm, and apples at 1.5 ppm. Barium is found in all food groups with the highest levels in nuts. Blueberries with very high levels of barium have been reported.

Levels of barium at 2,000 ppm in the soil inhibit the growth of some plants. However, if compounds of sulfur (S) and calcium (Ca) are in the soil then toxicity effects of barium are reduced.

The leaves of some nut trees have barium levels above 10,000 ppm! Some Brazil nuts have also been reported with 10,000 ppm of barium.


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Some species of yeast have a high affinity for barium where it accumulates on their surface.

Sources: coal and coal ash, artificial fertilizers made from phosphate rocks, re-mineralizer

57) **Lanthanum (La)** - Lanthanum is the first element of a group that we call the "Rare Earth" elements or "Lanthanides". If one looks at the Periodic table below, notice the two rows at the bottom where they are grouped together as they have almost identical chemical properties. However, they have very different magnetic properties.

The Path to Health for plants and those that grow and eat them.



1 H Hydrogen 1.0079																	2 He Helium 4.0026															
3 Li Lithium 6.941	4 Be Beryllium 9.0122																	5 B Boron 10.881	6 C Carbon 12.0107	7 N Nitrogen 14.0067	8 O Oxygen 15.9994	9 F Fluorine 18.9984	10 Ne Neon 20.1797									
11 Na Sodium 22.9897	12 Mg Magnesium 24.305																	13 Al Aluminum 26.9815	14 Si Silicon 28.0855	15 P Phosphorus 30.9738	16 S Sulfur 32.065	17 Cl Chlorine 35.453	18 Ar Argon 39.948									
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.9559	22 Ti Titanium 47.867	23 V Vanadium 50.9415	24 Cr Chromium 51.9961	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.9332	28 Ni Nickel 58.6934	29 Cu Copper 63.546	30 Zn Zinc 65.409	31 Ga Gallium 69.723	32 Ge Germanium 72.64	33 As Arsenic 74.9216	34 Se Selenium 78.96	35 Br Bromine 79.904	36 Kr Krypton 83.798															
37 Rb Rubidium 85.4678	38 Sr Strontium 87.62	39 Y Yttrium 88.9059	40 Zr Zirconium 91.224	41 Nb Niobium 92.9064	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.9055	46 Pd Palladium 106.42	47 Ag Silver 107.8682	48 Cd Cadmium 112.411	49 In Indium 114.818	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.6	53 I Iodine 126.9045	54 Xe Xenon 131.293															
55 Cs Cesium 132.9055	56 Ba Barium 137.327																	72 Hf Hafnium 178.49	73 Ta Tantalum 180.9479	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.078	79 Au Gold 196.9665	80 Hg Mercury 200.59	81 Tl Thallium 204.3833	82 Pb Lead 207.2	83 Bi Bismuth 208.9804	84 Po Polonium (209)	85 At Astatine (210)	86 Rn Radon (222)
87 Fr Francium (223)	88 Ra Radium (226)																	57 La Lanthanum 138.9055	58 Ce Cerium 140.116	59 Pr Praseodymium 140.9077	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.9253	66 Dy Dysprosium 162.5	67 Ho Holmium 164.9303	68 Er Erbium 167.259	69 Tm Thulium 168.9342	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.967
		89 Ac Actinium 227.03	90 Th Thorium 232.0381	91 Pa Protactinium 231.0359	92 U Uranium 238.0289																											

<ul style="list-style-type: none"> NPK Solids Liquids 	<ul style="list-style-type: none"> Gases Not natural on Planet Earth, Not in OceanSolution.
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Lanthanum is found in igneous rocks at 30 ppm, shale at 20 ppm, and very little in sandstone or limestone. Soils average around 30 ppm, and very little are found in fresh or seawater. However, marine plants can have 10 ppm.

Most of the rare earth elements are not rare in nature but often occur together in various minerals and were hard to separate (hence the name "rare"). Cigarette lighter flints are alloys of iron (Fe), lanthanum (La), cerium (Ce), and small amounts of praseodymium (Pr) and neodymium (Nd).

Rare earth elements when oxidized are very heat-resistant and glow brightly when hot; thus, they are used in lantern mantles heated by burning gas (ex. gasoline camping Lanterns).

Lanthanum's most common electrical or oxidation state is +3 (as are most of the other rare earths).

Lanthanum is often found in igneous rocks and in phosphorites used to produce artificial fertilizers. It is used to produce colored glass and electronic components.

Sandy soils have the least amount of this element with loamy soils the most. Organic matter has a high capacity to bind this element to levels 10X that of surrounding soil. Lanthanum is only slightly soluble hence, it is not very mobile in soils, however microorganisms and earthworms in the soil help release this element.

It is believed that this element is involved with the regulation of metabolism in both plants and animals including humans even though direct evidence has not been found. Lanthanum is found in human bones, the liver and kidneys.

When added to animal feed it improves weight gain and feed conversion to body mass in all farm animals (chickens, ducks, cattle, pigs, etc.). It also improves milk production in cows and egg production in chickens.

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Gardening and Landscaping Problems Associated with Lanthanum (La)

Horticultural research in the United States has largely ignored this element while China has been using it for decades.

Fertilizers enriched with this element stimulate seed germination, seedling growth, and chlorophyll content.

Research in China has found both yield increase and quality improvements across a wide range of crops when *lanthanum and other members of this family of rare earth elements were present in the soils.*

There is not any clear evidence of toxic effects of this element on plants; however, it does have an impact on cell membranes of vascular plants and on calcium (Ca) metabolism in some microorganisms.

Mosses tend to accumulate this element, as do *Carya* species. Some hickory trees have been found to accumulate up to 2,300 ppm of this element. Woody plants in general have the ability to absorb more of this element. The concentration of lanthanum found in plants range from below 1 ppb to over 15,000 ppm.

The yeast (*Candida albicans*) can absorb up to 370 ppm per day. It is proposed this may be how *Candida* causes a debilitating energy sapping disease by stealing lanthanum from the patient.

Sources: fly ash, sewage sludge, animal manures, sands of igneous rock, re-mineralizer

58) Cerium (Ce) - Cerium is the second member of a group that we call the "Rare Earth" elements or "Lanthanides". It is a reactive grey metal that will tarnish in air, and will burn if

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scratched with a knife. The most common electrical or oxidation state is +3 (it is also stable at a +4 state). Even though it is called a rare earth, it is almost as common as zinc (Zn) and four times more common than lead (Pb).

Cerium is found in igneous rocks at 60 ppm, shale at 59 ppm, sandstones at 92 ppm, and limestone at 12 ppm. Fresh and seawater have very little cerium. Soils average 50 ppm, and land plants can accumulate 320 ppm. Land animals have only 0.003 ppm.

Cerium is added to diesel fuel to lower the soot ignition temperature allowing it to be trapped by filters. Cerium oxide (CeO_2) is part of catalytic convertors to clean up car exhaust and it is also used to polish glass.

Cerium compounds were used in gas incandescent mantles in the late 1800's to create a bright light. It is used in medicine to treat topical burns and cerium sulfide (Ce_2S_3) is used as a red pigment for plastics.

Cerium is used in flat screen monitors and televisions, and long-life low energy light bulbs. Compounds of cerium are used in many appliances and devices.

For years it was believed that cerium has no known biological role; however, cerium salts can stimulate metabolism, lowering cholesterol levels, blood pressure, appetite, and risk of blood coagulation. Cerium is considered non-toxic to animals and humans as the body rapidly excretes it. However, animals that were injected, with large doses of cerium, had a heart attack and died.

A dilute solution of cerium nitrate $Ce(NO_3)_3$ is an effective treatment for bathing the skin of humans with 3rd degree burns.

Gardening and Landscaping Problems Associated with Cerium (Ce)

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Very little is known about cerium and how it affects plants. The amount found in plants correlates to the amount in soils. A few plants will accumulate cerium (*Carya sp.* accumulate cerium to 320 ppm).

Sources: some phosphate rocks, igneous rocks, sewage sludge, re-mineralizer

59) Praseodymium (Pm) - Praseodymium is the third member of a group that we call the "Rare Earth" elements or "Lanthanides". It is found in igneous rocks at 8 ppm, shale at 6 ppm, sandstone at 2 ppm and limestone at 1.4 ppm. Marine plants have 5 ppm and land plants have up to 46 ppm. Marine animals have 0.5 ppm and land animals have 1.5 ppm where in mammals it accumulates in the bone and liver. Seawater has only 1 ppt (parts per trillion).

Praseodymium is used to make special glass lens that glass blowers use to protect their eyes and it is used to give glass and pottery glaze a clear yellow color.

Praseodymium is used in magnets and many types of lighting. It has the unique property, that when exposed to magnetic fields, it lowers its temperature and has helped scientists' approach within 1/1,000 th of a degree of absolute zero.

It is used in making carbon arc lights to create daylight white light for motion picture filming and it creates the color in fake cubic zirconia-based peridot.

Praseodymium is used to alloy with magnesium (Mg) to increase strength where it is used in aircraft engines.

For years it was believed that praseodymium has no known biological role; however recent research has shown praseodymium salts enhances proliferation of normal cell growth and doubles the life span in laboratory test species.

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Gardening and Landscaping Problems Associated with Praseodymium (Pm)

Plants do not absorb praseodymium very well; hence, vegetables only have 1-2 ppb in them, so very little gets into the food chain.

Sources: mineral sands of igneous rocks, re-mineralizer

60) **Neodymium (Nd)** - Neodymium is a bright silvery-white metal that quickly tarnishes when exposed to air. This metal is different from the other lanthanides as it has three oxidation or electrical states (+2, +3 and +4).

This member of the rare earth family is found in igneous rocks at 28 ppm, shale at 16 ppm, sandstone at 11 ppm and limestone at 4 ppm. Marine plants have 5 ppm but land plants can have 460 ppm as in some *Carya* species (Hickories). Marine animals have 0.5 ppm. In mammals, it accumulates in the bone and liver.

When neodymium (Nd) is combined with iron (Fe) and boron (B) where it is called NIB, it makes excellent strong permanent magnets. These magnets are so strong they can be dangerous to be around. These magnets are used to make stud-less jewelry.

It is used in crystal matrices to make quantum memory devices and it allowed for the miniaturization of many electrical components. Neodymium is used in alloys of high strength, computer hard drives, mobile phones to wind turbines and hundreds of products. Neodymium is now being used to make quantum computers as the element can hold photons for a few nanoseconds.

If neodymium oxide (Nd_2O_3) is added to molten glass, the result is a beautiful deep lavender color. Neodymium glass is also used to produce powerful lasers.

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For years it was believed that neodymium has no known biological role. However, Neodymium is a lighter rare earth element that is proven to enhance normal cell growth and double the lifespan of laboratory species.

Neodymium can have other effects of the human body. Neodymium salts and dust are very irritating to the eyes. If ingested the salts are only slightly toxic if they are soluble and non-toxic if they are insoluble.

The level of neodymium in sewage is less than the other lanthanides which suggest more of it is retained in our bodies.

Gardening and Landscaping Problems Associated with Neodymium (Nd)

Neodymium is not readily absorbed by plants as it only averages around 10 ppb hence very little enters the food chain. However, some plants can accumulate up to 3,000 ppb.

Sources: mineral sands of igneous rocks, re-mineralizer

61) **Promethium (Pm)** - Do to the unique arrangement or protons and neutrons there is no stable arrangement or stable isotopes of this element. Promethium is radioactive with a half-life of 2.6 years; as a result, promethium did not exist in nature (biosphere) until nuclear explosions occurred.

Promethium was once used to make luminous dials for watches and luminous paints and was used in some electrical devices.

If ingested it accumulates in the bones and liver of mammals. Promethium has no role in any living thing.

Gardening and Landscaping Problems Associated with Promethium (Pm)

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None

Sources: nuclear fall out

62) **Samarium (Sm)** - Samarium is a "light" rare earth element and is found in igneous rocks at 6 ppm, shale at 5.6 ppm, and sandstone at 2.7 ppm. In pure form, it is a silvery-white metal that is stable in air.

Samarium-cobalt magnets are not as strong as others mentioned but they can operate at higher temperatures where other types would lose their magnetism. Samarium is used in electrical devices and in chemical and medical research.

Samarium is found in both marine animals and land animals at less than 1 ppm. For years it was believed that samarium had no known biological role. However, as in other rare earth elements when present, samarium enhances normal cell growth and doubles the life span of laboratory species. Samarium salts also stimulate metabolism.

Gardening and Landscaping Problems Associated with Samarium (Sm)

Normally land plants have very little samarium in them (less than 1 ppm) as it is not taken up by roots; however, a few plants can accumulate up to 23 ppm.

Sources: mineral sands of igneous rocks, re-mineralizer

63) **Europium (Eu)** - As you might have guessed, Europium is named for the continent Europe and is the 50th most common element on earth. It is a soft silvery metal and reacts readily with water and oxygen. Europium is found in igneous rocks at 1-2 ppm, shales and sandstones at 1 ppm.



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Unlike other rare earth elements, the value of Europium is not on magnetism but on luminosity. Paints made from this element can glow for many minutes or even hours after being exposed to a strong light source. It is used in cathode ray tubes (CRT), monitors, television set, etc. It is used in many types of compact fluorescent light bulbs. This element is so reactive that it will oxidize over time even when stored under oil.

Europium is not easily absorbed by plants hence very little gets into the food chain. In traditional thought it has no known biological role. However, laboratory animals fed diets with Europium present increase their lifespan by 100%.

Research from Ludwig-Maximilians-University published in the journal ChemBioChem 2018 has found the bacterium *Methylacidiphilum fumariolicum* uses europium to make an enzyme that converts methanol into formaldehyde. Its active site consists of the cofactor PQQ (pyrroloquinoline quinone) which is critical for many biological functions from microbes to humans.

Gardening and Landscaping Problems Associated with Europium (Eu)

Present in some plants at 30-130 ppb (parts per billion), however most vegetables are far less at 0.04 ppb. Members of the *Carya* family often have 16 ppm.

Sources: mineral sands of igneous rocks, re-mineralizer

64) **Gadolinium (Gd)** - Gadolinium is another member of the "Rare Earth" group. Gadolinium is a silvery-white, malleable, and ductile metal. It is found in nature only in oxidized form, and even when separated, it usually has impurities of the other rare earths.

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It is found in igneous rocks at 5.4 ppm, shales at 4.3 ppm, sandstones at 2.6 ppm, and very little in limestone at 0.7 ppm. Gadolinium is the 41st most common element on earth and is more common than tin (Sn).

Many gardeners know the importance of para-magnetism to have healthy gardens. Gadolinium compounds are highly paramagnetic. This property makes this element very useful in medical applications where it improves contrast for procedures like MRI's. One example is injecting gadopentetate dimeglumine ($C_{14}H_{18}GdN_3O_{10}$) into one's blood stream and the MRI will show where the blood is going (showing the exact location of internal bleeding).

Gadolinium also has the unique property of going from ferro-magnetic to para-magnetic at near room temperatures (Currie point). In ice water, it will stick to a magnet but as it warms up it and becomes paramagnetic, it will fall off.

Gadolinium will also absorb neutrons and is used in nuclear reactors. Gadolinium is also used in microwave applications.

Very little gadolinium is found in the human body, however if ingested it quickly accumulates in the bones and liver of land mammals. Gadolinium has no known biological role but its salts stimulate metabolism.

Gardening and Landscaping Problems Associated with Gadolinium (Gd)

Most plants do not absorb gadolinium into their roots hence very little enters the food chain. A few land plants can absorb up to 70 ppm of this element, particularly the *Carya* species.

Sources: mineral sands of igneous rocks, re-mineralizer

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65) **Terbium (Tb)** - Terbium is a soft silvery metal that is slowly oxidized in air and will react with cold water (most elements react with hot water). Terbium is found in the earth's crust at 1 ppm and is the 57th most abundant element (twice as common as silver). It is found in igneous rocks at 0.9 ppm, shales at 0.58 ppm, and limestone at 0.07 ppm. Land plants have only 0.0015 ppm and land animals at 0.0004 ppm.

This element has the unique property that it will change its shape when placed in a magnetic field. This means a rod will grow longer or shorter depending on the magnetic field. This allows any solid material to be turned into a loud speaker; hence, it is used in many speaker applications. In making glass it is used as a coloring agent giving glass a beautiful red color.

The amount of terbium in the human body is not known, and has no known biological role. Very little terbium is absorbed by plant roots hence very little gets into the food chain. Vegetables that have been studied had less than 1 ppb in them. The small amount absorbed by humans ends up in the bones.

Terbium is a rare earth element and is four times more costly than platinum. It is commonly used in lasers and low energy lighting.

Gardening and Landscaping Problems Associated with Terbium (Tb)

No known issues, good or bad.

Sources: mineral sands of igneous rocks, re-mineralizer

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