

Trace Elements and Human Health

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Outline

- what are trace elements and where do they come from?
- essential trace elements
 - e.g. selenium
- non-essential trace elements
 - e.g. mercury, lead

Trace elements

Periodic Table

Main groups

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http://session.masteringgenchem.com/assets/help/periodic_table.gif

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3 Li 6.941	4 Be 9.01218	Transition metals										5 B 10.811	6 C 12.0107	7 N 14.0067	8 O 15.9994	9 F 18.9984	10 Ne 20.1797
11 Na 22.9898	12 Mg 24.3050	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8 9 10		1B 11	2B 12	13 Al 26.9815	14 Si 28.0855	15 P 30.9738	16 S 32.065	17 Cl 35.453	18 Ar 39.948	
19 K 39.0983	20 Ca 40.078	21 Sc 44.9559	22 Ti 47.867	23 V 50.9415	24 Cr 51.9961	25 Mn 54.9380	26 Fe 55.845	27 Co 58.9332	28 Ni 58.6934	29 Cu 63.546	30 Zn 65.39	31 Ga 69.723	32 Ge 72.64	33 As 74.9216	34 Se 78.96	35 Br 79.904	36 Kr 83.80
37 Rb 85.4678	38 Sr 87.62	39 Y 88.9059	40 Zr 91.224	41 Nb 92.9064	42 Mo 95.94	43 Tc [98]	44 Ru 101.07	45 Rh 102.9055	46 Pd 106.42	47 Ag 107.8682	48 Cd 112.411	49 In 114.818	50 Sn 118.710	51 Sb 121.760	52 Te 127.60	53 I 126.9045	54 Xe 131.293
55 Cs 132.9055	56 Ba 137.327	71 Lu 174.967	72 Hf 178.49	73 Ta 180.9479	74 W 183.84	75 Re 186.207	76 Os 190.23	77 Ir 192.217	78 Pt 195.078	79 Au 196.9666	80 Hg 200.59	81 Tl 204.3833	82 Pb 207.2	83 Bi 208.9804	84 Po [208.98]	85 At [209.99]	86 Rn [222.02]
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Actinide series	89 Ac [227.03]	90 Th 232.0381	91 Pa 231.0359	92 U 238.0289	93 Np [237.05]	94 Pu [244.06]	95 Am [243.06]	96 Cm [247.07]	97 Bk [247.07]	98 Cf [251.08]	99 Es [252.08]	100 Fm [257.10]	101 Md [258.10]	102 No [259.10]

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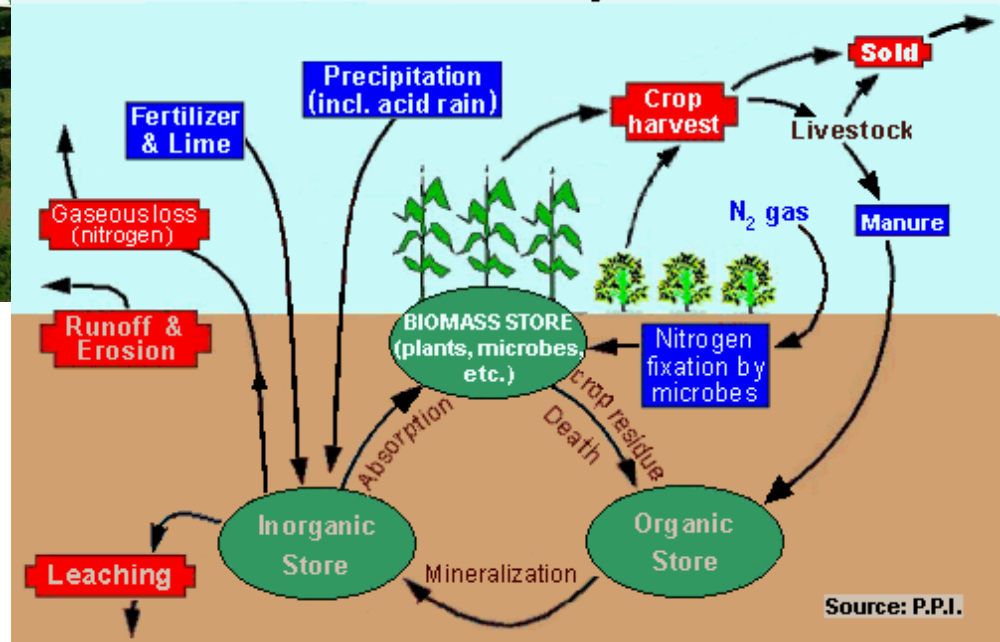
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Sources



The General Soil Nutrient Cycle component Input Loss



Sources

- found in low concentrations in soils and rock
 - low parts per million (ppm)
 - metals and non-metals
 - exposure
 - via diet: soil → plants → humans
 - or soil → plants → animals → humans
 - or multivitamins
 - weathered rock, compost, manures
 - via occupational exposure
 - mining, refining (especially gold)
 - concentrations in soils, plants, diets vary

Classification

- essential, probably essential, non-essential
 - required by humans - 50 μg (0.05 mg) – 18 mg per day
 - iron, zinc, copper, chromium, iodine, cobalt, molybdenum, and selenium
 - probably required, or beneficial
 - silicon, manganese, nickel, boron, and vanadium
 - not required
 - lead, mercury, cadmium, thallium, arsenic

Health

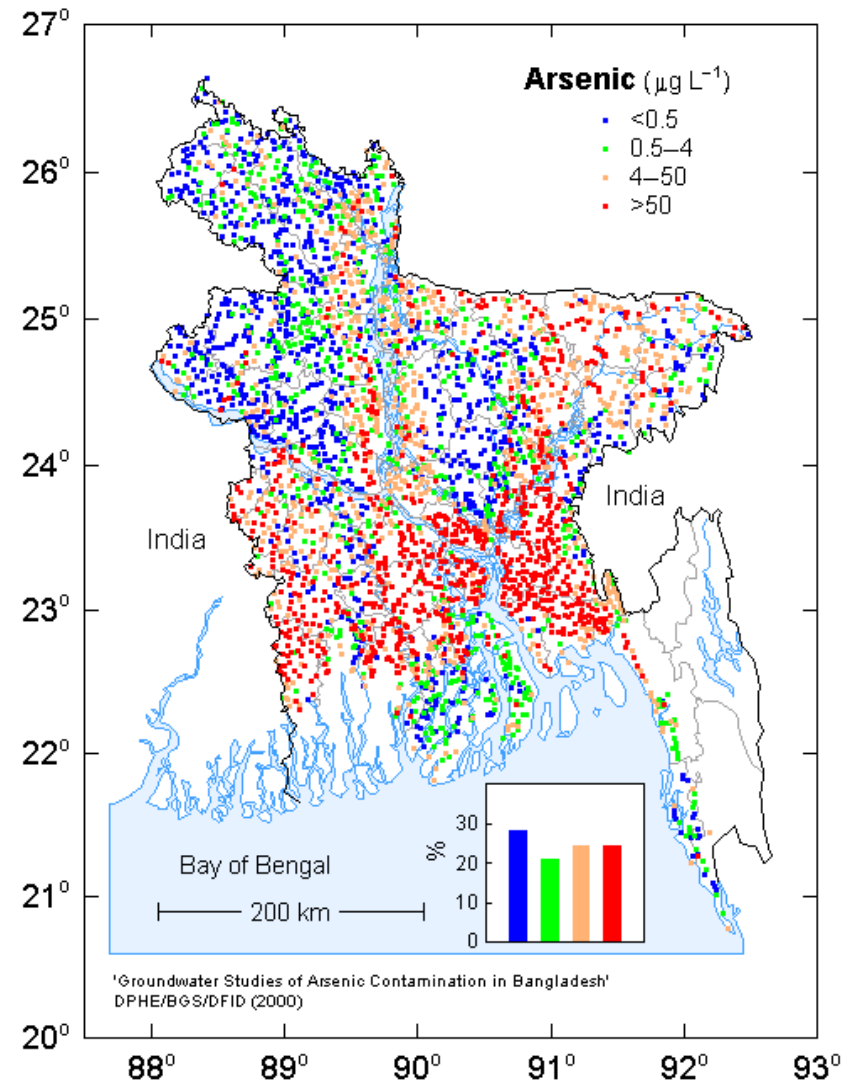
- health problems
 - from consuming toxic levels of non-essential trace elements
 - e.g. mercury, lead
 - from consuming essential trace elements at levels that are either too low or too high
 - e.g. selenium, iodine

Arsenic

- non-essential
 - World Health Organization standard of 10 ppb for drinking water
 - maximum uptake of ~ 130 $\mu\text{g}/\text{day}$ for an adult
 - sources:
 - naturally present in groundwater, soil
 - water \rightarrow people
 - soil \rightarrow plants \rightarrow people
 - industrial and agricultural sources
 - pesticides, wood preservatives

Arsenic

- Bangladesh
 - over 50 million people drinking water in excess of WHO standards
 - shallow tube wells to avoid water contaminated with bacteria
- SE Asia also contains areas high in arsenic



Arsenic

- acute poisoning
- chronic effects
 - links to skin, lung, and bladder cancer

Arsenic

- a difficult issue
 - drill deeper wells
 - different plant varieties differ in element accumulation
 - distill drinking water or use specialized filters to absorb dissolved arsenic

Mercury

- non-essential
 - very toxic; bioaccumulates in fat tissue
 - maximum recommended uptake of ~ 30 $\mu\text{g}/\text{day}$ for an adult
 - sources
 - food, especially seafood
 - older fish, top predators (shark, tuna)
 - occupational
 - mercury used to purify gold from ores

Mercury



Mercury used by artisanal gold miner



A miner burning mercury-gold amalgam

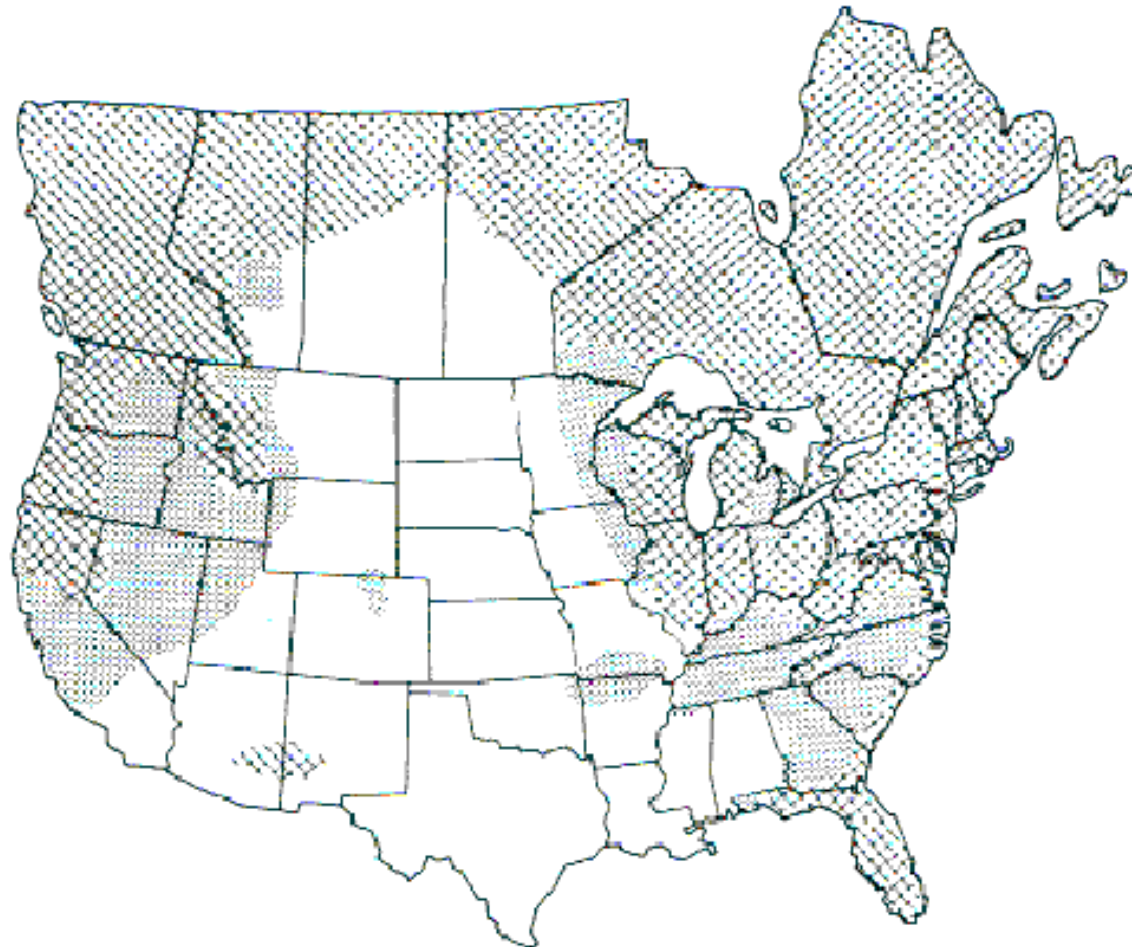
Mercury




- Mercury contamination
 - S. America
 - Africa: Lake Victoria
 - technology to recover mercury
 - tube retort:
www.youtube.com/watch?v=KL9deyMSzs8&feature=related

Selenium

- recommended daily intake (RDI)
 - 20 $\mu\text{g}/\text{day}$ (children) to 50-70 $\mu\text{g}/\text{day}$ (adults; pregnant and nursing mothers)
 - greater than 45 (infants)-400 μg (adults) can be toxic
 - intake depends on what is consumed and the Se content of the soil it was grown in

Selenium



-  LOW-APPROXIMATELY 80% OF ALL FORAGE AND GRAIN CONTAIN < 0.10 PPM SELENIUM
-  VARIABLE-APPROXIMATELY 50% CONTAIN < 0.10 PPM SELENIUM INCLUDES ALASKA
-  ADEQUATE-80% OF ALL FORAGES AND GRAINS CONTAIN < 0.10 PPM SELENIUM INCLUDES HAWAII

Selenium

- soil
 - 0.01 – 2 – 38 ppm
 - Se-rich soils
 - Canadian and American Prairies
 - parts of the Amazon
 - parts of China and India
 - Se-poor soils
 - parts of China
 - much of sub-Saharan Africa

Selenium

- deficiency
 - Keshan-Beck disease: heart troubles
 - HIV/AIDS: speeds progression of disease; higher death rates
 - selenium promotes immune response
 - links between selenium deficiency and certain cancers
 - white muscle disease and other ailments in livestock

Selenium

- toxicity
 - selenosis: hair loss, garlicky breath, birth defects
 - links to certain cancers
 - “blind staggers” in livestock over-consuming selenium

Conclusion

- consumption of trace elements unavoidable
 - health concerns can arise in unique situations
 - limited consumption of required trace elements
 - excessive consumption of any trace element
 - a number of global ‘hot spots’