8. MINERALS

organogenic elements:	C, O, H, N, P, S
minerals:	P, S, others (ash elements)
rough content:	ash (0,5 – 3 %)

classification

- according to quantity (very variable viewpoint)
  macro (majority) elements: >100 mg/kg (ppm) = 0,01%
  Na, K, Mg, Ca, Cl, P, S
  micro (minority) elements: 10 – 100 mg/kg
  Fe, Zn
  trace elements: < 10 mg/kg
  Al, As, B, Cd, Co, Cr, Cu, F, Hg, I, Mn, Mo, Ni, Pb, Se, Sn
  ultra trace elements: < 1 μg/kg (ppb)

- according to physiological importance
  essential (indispensable), functionally beneficial
  Na, K, Mg, Ca, P, S
  Fe, Zn, Mn, Cu, Ni, Co, Mo, Cr, Se, I, F, B, Si

  As additives (recommended daily intake v mg)

Ca	800	P	800	Fe	14
Mg	300	Zn	15	I	0,15

  non-essential (physiologically inactive)
  Li, Rb, Cs, Ti, Au, Sn, Bi, Te, Br, Al

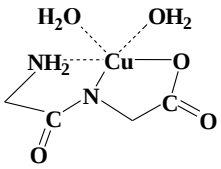
  toxic
  Pb, Cd, As, Hg
  Fe, Zn, Cr, Cu, Ni, Se, Al, Sn (in legislation)

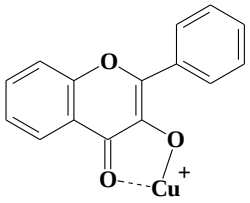
  toxic anions: NO_3^-, NO_2^- (legislation), CN^-, SCN^-
  radionuclides : nuclides with unstable nuclei subjected to radioactive decay

forms of occurrence (book 2, tab. 6.2)
elemental form
ions (free, hydrated)
little soluble inorganic and organic compounds
complex compounds with inorganic ligands
complex compounds with organic ligands
covalent compounds (non-metals and semi-metal)
organometallic compounds

complexes with proteins, metaloproteins (book 2, tab. 6.3)
(catalysts, transportation, spare storage compounds)

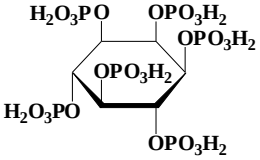
Fe
heme enzymes: cytochromes, catalase, peroxidase
non-heme enzymes: succindehydrogenase, xanthinoxidase, flavin oxidoreduktase, aconitase
transport proteins: hemoglobin (erythrocytes), myoglobin (muscles) O_2, transferrin (plasma) Fe
storage proteins: ferritin, homosiderin (spleen, liver, bones)
complexes with other compounds



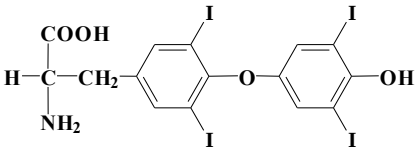


dipeptide complex with Cu^{2+} flavonol complex with Cu^{2+}

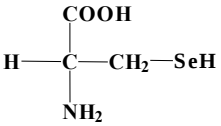
covalent compounds



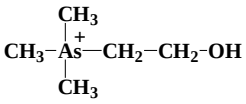
fytová kyselina



thyroxin



selenocystein



arsenobetain

(phytic acid, methylmercury)

biochemical function of essential elements
majority elements
Na
osmotic pressure, acid-basic equilibrium, enzymes activation

K
osmotic pressure, acid-basic equilibrium, enzymes activation, muscle activity

Cl
osmotic pressure, (combined with K^+, Na^+ /Cl^-), digestion (HCl)

Mg
building function, muscle and neural activity, blood coagulation

P
building function, energetic metabolisms, enzymes activation, catalytic, regulative functions

S
biocatalysts (components of proteins/vitamins)

minority elements

Fe	catalytic, transport activity
Zn	catalytic activity

trace elements

Cu	catalytic, transport activity (O_2 / invertebrates)
Mn	activation, catalytic activity
Ni	catalytic activity (plants, mikroorganisms)
Co	catalytic activity (vitamin B_{12})

Mo	catalytic activity (plants, microorganisms)
Cr	catalytic activity (glucose-tolerant factor)
V	activation
Se	catalytic activity (connection with vitamin E)
I	regulatory activity (hormones thyroid gland)
F	building function (bones and fees)
B	activation, building function (plant, pectin)
Si	building function (collagen, mucopolysaccharides)

nutrition

daily intake

majority elements

Na	500 mg	Cu	1,5 - 3
K	2000	Mn	2 – 5
Cl	75	Ni	not determine (0,15–0,7)∗
Mg	350	Co	not determine (0,005–0,01)∗
Ca	800	Mo	0,08 – 0,25
P	1200	Cr	0,05–0,2
S	not determine (100 – 600)∗	V	not determine (0,01–0,03)∗

minority elements

Fe	10 – 15	Zn	10 – 15

trace elements

Se	0,01 (children)–0,07 (men)	B	not determine (2 – 10) ∗
I	0,04 – 1,5	Sn	not determine (3) ∗
F	0,1 – 4	Si	not determine (20 – 50) ∗

∗ = intake / day

occurrence and important sources (book 2, tab. 6.4)

majority elements

Na NaCl (~ 75%) NaH-glutamate
K tea, coffee, other plant foods
Cl NaCl, contaminants (persistent pesticides, PCB, 3-MCPD), additives (including chlorinated water)
Mg cereals, legumes, other plant foods
Ca cheese, milk, fish, yolk, legumes
P milk, cheese, yolk, legumes, nuts, additives (mostly phosphates)
S eggs, meat, cereals, legumes

minority elements

Fe meat, eggs, legumes, special cheeses, tea, cacao, additives and contaminants
Zn meat, eggs, legumes, tea

trace elements

Cu cheeses, cereals, legumes, tea, mushrooms, contaminants
Mn cereals, legumes, forest fruits, tea, spices, meat
Ni cereals, legumes, nuts, tea, cacao, contaminants
Co cereals, cereals, nuts, tea
Mo cereals
Cr yeast, tea, cereals, contaminants

V cereals
Se fish, invertebrates, eggs, plants (fortification)
I fish and algae, meat, cheese, eggs, fortification
F tea, fortification
B cereals, nuts, fruits
Si cereals, cereals

utilisation
forms, resorption

Ca

generally from foods	5 – 15 %
bread	40 % phytin
cabbage	40 – 70 %
oxalates	2 – 5 % oxalic acid

P
cereals, legumes:
phytic acid (phytin), partly splitted by phytases (microorganisms)
phytic acid $\rightarrow$ partial esters + H_3PO_4
additives: phytic acid, salts H_3PO_4, polyphosphates (water binding)

Fe
resorption 5 – 15%, Fe (II) > Fe (III), Fe in hem
phytates (Fe, Zn), phenolic compounds
additives: elementary Fe, inorg. a org. compounds (fumarate, baby foods)

I
iodination of salt, foods
antithyreoid compounds: natural (goitrin and other goitrogens), contaminants (PCB, pesticides, veterinary drugs)

contaminants
content in food (book 2, tab. 6.13)
tolerable amount in food (book 3, tab. 12.4)
toxicologic limits
natural sources of contamination

- efflorescence of rocks
- fires
- volcanic activity
- flooding

anthropogenic sources of contamination

- burning of fossil fuels
- transportation
- industry (especially production of metals)
- agriculture (fertilizers and other chemicals)
- wastes

Pb
accumulators, sheet metal, pipes, solder (metal packaging material), painting material and pigments, additives in gasoline: Pb $(C_2H_5)_4$

Cd
anticorrosion protection (painting), painting material and pigments (CdS), PVC stabilizers (salts of fatty acids), phosphates as fertilizers, smoking

Hg
volcanic activity, burning of coal, agrochemicals (phenylmercurichloride), wastes (bateries, switches, electrodes, thermometers, amalgams)
biochemical transformations: biomethylation (organomercury compounds), microorganims, microscopic fungi

As
metallurgy, burning of coal, agrochemicals, veterinary drugs, pigments
chemical transformation: fish

toxic anionts
nitrates and nitrites
content
high: vegetables (root crops)
low: fruits (melon, banana)

acceptable amout of nitrates (book 3, tab. 12.6)
food classification

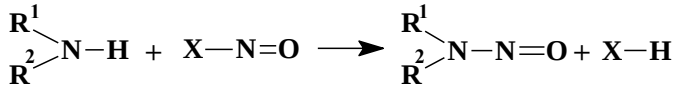
- with high content (> 1000 mg.kg^{-1})
  lettuces, endive, spinach, spinach beet, Chinese cabbage, radish, celery, rhubarb, corn

- with median content (250-1000 mg.kg^{-1})
  cabbage, kale, cauliflower, eggplant, parsley, carrot, broccoli, garlic, potato

- with low content (< 250 mg.kg^{-1})
  Brussels sprouts, onion, tomato, pea, cucumber, artichoke, asparagus

ADI (NO_3^-) = 3,5 mg/kg, ADI (NO_2^-) = 0,2 mg/kg (lethal dosage 32 mg/kg)

methemoglobin
hemoglobin (Fe^{2+}) + NO_2^- → methemoglobin (Fe^{3+}) + NO
first symptoms: 6-8 % of methemoglobin
formation of carcinogenic nitrosamines from secondary amines:



sekundární amin secondary amine
nitrosační činidlo nitrosation agent
***N*-nitrosamin** *N*-nitrosamine

content in foods (book 3, tab. 12.7, 12.8)