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Environmental Toxicity and Impact Assessment Models for Metals

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Estimating potential hazard to the environment

- Toxicity ➡ LC_{50}
- Persistence ➡ ½ life
- Bioaccumulation ➡ $\frac{\text{body burden}}{\text{exposure}}$

- the P B T criteria -

Origins of the P&B Criteria

Highly Toxic Synthetic Organic Substances

- DDT
- lack of chronic toxicity data

How do you assess the environmental hazard

- predicting chronic effects of organics ?

Persistent if

½ life ≥

air: 2 days

surface H_2O: ½ yr

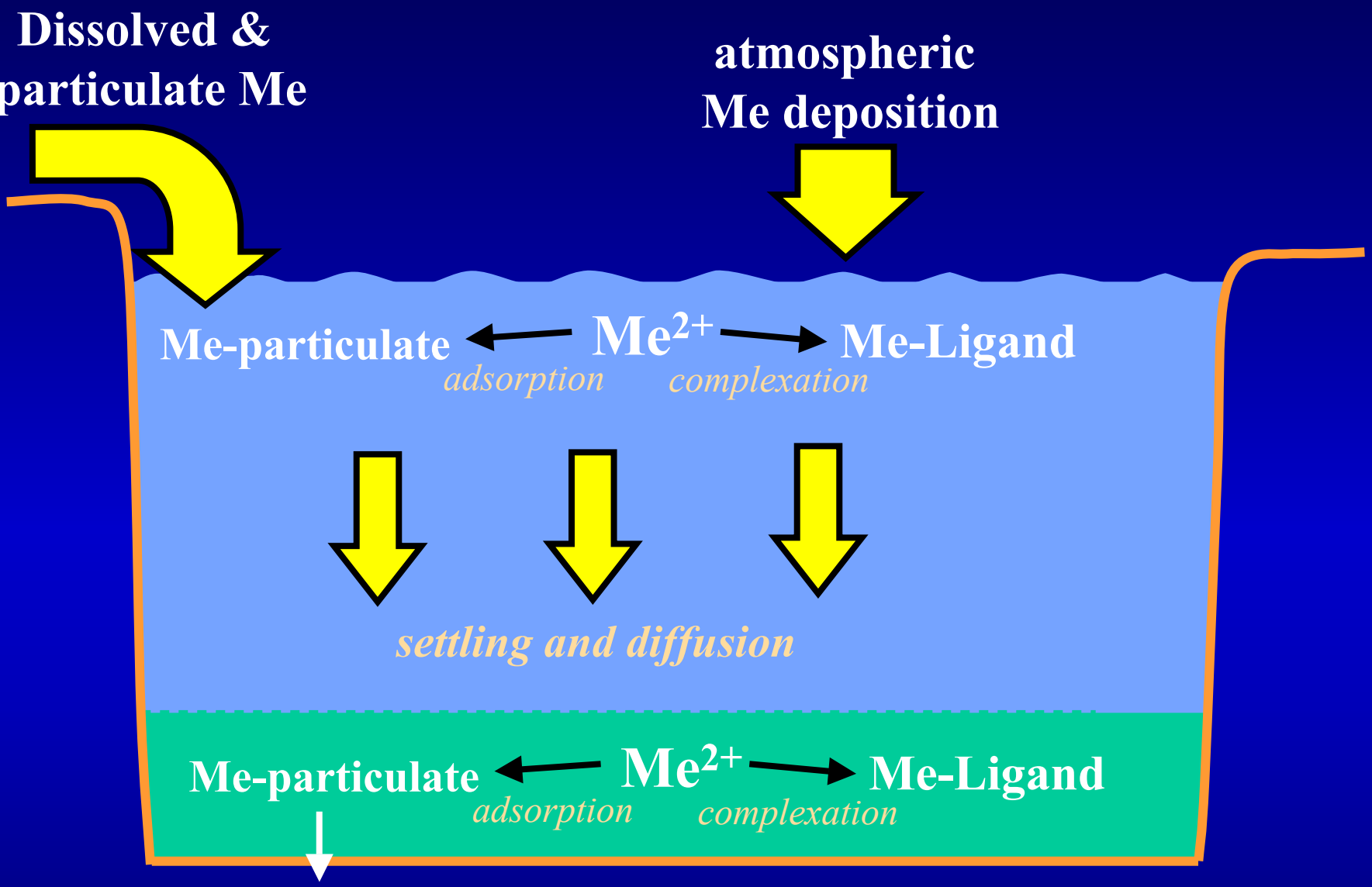
sediments: 1 yr

soil: ½ yr

This is
THE PERIODIC TABLE OF THE ELEMENTS

1 H 1.008																	2 He 4.003
3 Li 6.939	4 Be 9.012											5 B 10.811	6 C 12.011	7 N 14.007	8 O 15.999	9 F 18.998	10 Ne 20.183
11 Na 22.991	11 Mg 24.312											13 Al 26.982	14 Si 28.086	15 P 30.974	16 S 32.064	17 Cl 35.453	18 Ar 39.948
19 K 39.102	20 Ca 40.08	21 Sc 44.956	22 Ti 47.90	23 V 50.942	24 Cr 51.996	25 Mn 54.983	26 Fe 55.847	27 Co 58.933	28 Ni 58.971	29 Cu 63.54	30 Zn 65.37	31 Ga 69.72	32 Ge 72.59	33 As 74.922	34 Se 78.96	35 Br 79.909	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.905	40 Zr 91.22	41 Nb 92.906	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.4	47 Ag 107.87	48 Cd 112.40	49 In 114.82	50 Sn 118.69	51 Sb 121.75	52 Te 127.60	53 I 126.9	54 Xe 131.30
55 Cs 132.91	56 Ba 137.34	57 La 138.91	72 Hf 178.94	73 Ta 180.95	74 W 183.85	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.09	79 Au 196.97	80 Hg 200.59	81 Tl 204.37	82 Pb 207.19	83 Bi 208.98	84 Po (210)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Ha (262)	106 Sg (263)	107 Ns (262)	108 Hs (265)	109 Mt (266)	110 Unn (272)								

58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (147)	62 Sm 150.35	63 Eu 151.96	64 Gd 157.25	65 Tb 158.92	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
90 Th 232.04	91 Pa (231)	92 U 238.03	93 Np (237)	94 Pu (242)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (249)	99 Es (254)	100 Fm (253)	101 Md (256)	102 No (254)	103 Lr (257)



adapted from DiToro et al 2000

Bioaccumulation

BCFs and BAFs for metals:

- are inversely correlated to exposure conc.
- are not intrinsic properties.
- do not reflect adverse effects.

Metal uptake is not constant over the exposure range

Metals have to be taken up to cause effects
- But, body burden is not predictive of chronic impact.

Bioaccumulation of Metals

- Internal concentration of metals can be regulated, particularly essential elements.

- There is essential, benign and toxic accumulation.

- Many factors influence and control accumulation

- Organisms respond to metal exposure and alter uptake, distribution and elimination.

- The responses to exposure and accumulation are specific to the metal and the species.

Alternatives

Dietary Toxicity / Trophic Transfer of Metals.

- link dietary toxicity to burden that causes it, (2° poisoning).
- accumulation in prey animals that may cause dietary toxicity in the predator.

Develop another measure of Chronic Toxicity.

- redefine a new bioaccumulation measure.
- use chronic toxicity itself.
- acute to chronic ratio.

Acute Toxicity

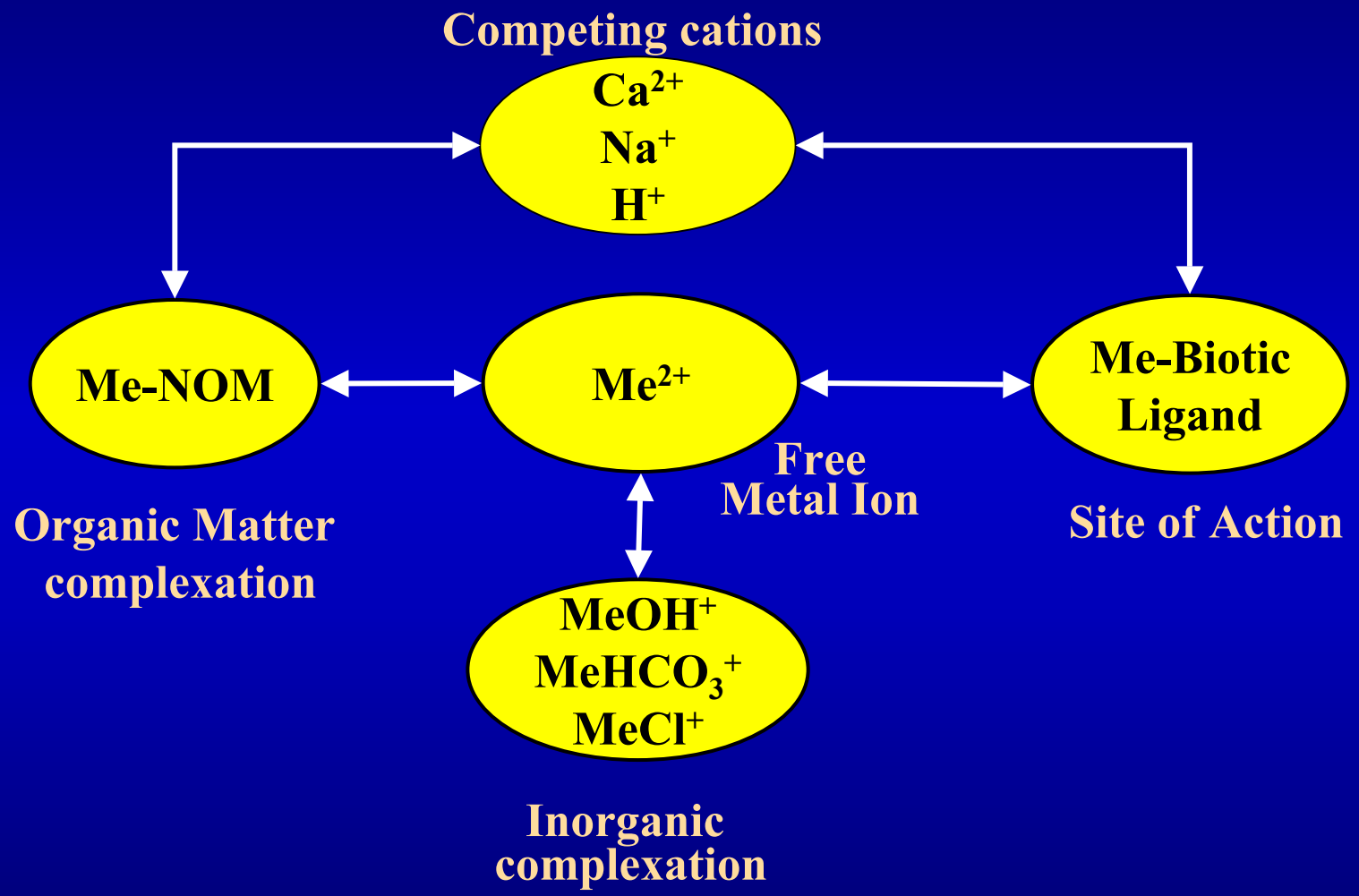
- wide variation in toxicity responses
- usually take a “worst case” approach

the endless search for the lowest number.

New mechanistically based models (BLM)

- combine toxicology, physiology, geochemistry & modelling.
- may work for chronic as well as acute.

Biotic Ligand Approach to Acute Toxicity.



From DiToro et al 2001

Conclusions

metal bioavailability and toxicity

Persistence

- of bioavailable forms

Bioaccumulation

- in relation to toxic impacts.

Toxicity

- linking bioavailability to toxicity.