UNIVERSITÄT HOHENHEIM
Landesanstalt für Landwirtschaftliche Chemie
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Sources and paths for Trace Elements in the feed chain

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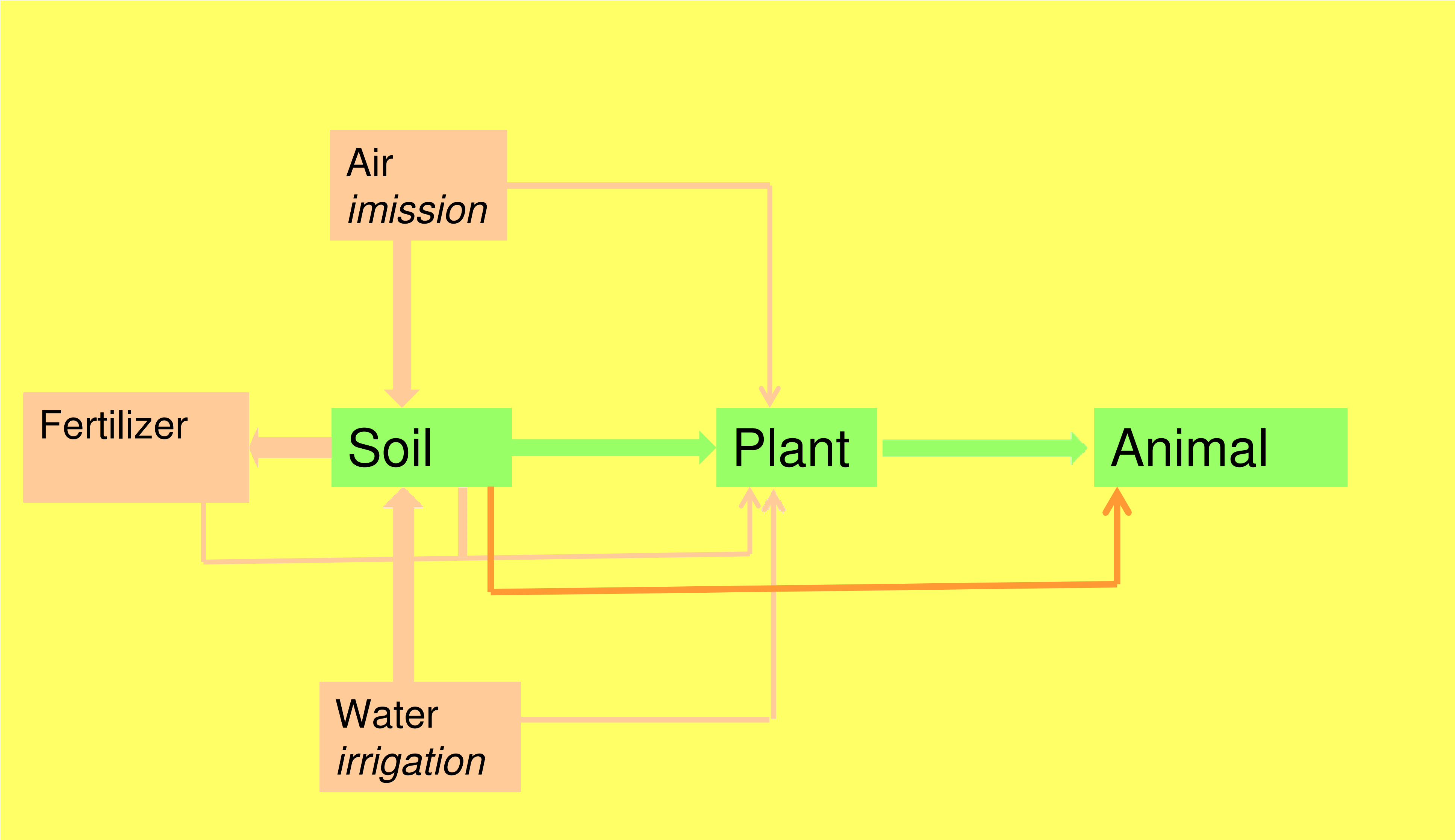
Sources and paths for Trace Elements in the feed chain

- Feed chain
- Sources
- Trace elements in feed and drinking water
- Trace element supplementation
- Trace element interaction
- Trace element excretion
- Summery

Essential trace elements and the sequence of discovery

Element	Discovery
Eisen	Sydenham (17. Jh.)
Jod	Coindet (1820), Chatin (1852)
Kupfer	Hart et al. (1928)
Mangan	Kemmerer et al. (1931), Orent und McCollum (1931)
Zink	Todd et al. (1934), Bertrand und Chattacherjee (1934)
Cobalt	Marston (1935), Lines (1935), Underwood und Filmer (1935)
Molybdän	Drea (1938)
Selen	Schwarz und Foltz (1957), Patterson et al. (1957)


Air
imission
Fertilizer
Soil
Plant
Animal
Water
irrigation

Paths

Feed

- (straight) feedstuffs
- modification by cultivation, harvest, processing etc.

- Supplements

Additional paths:

- Drinking water, liquid supplements
- Bedding material, inorganic materal (antimicrobial)
- Soil
- Abrasion, corrosion
- Stable installations
- other contact materials

Paths

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Abrasion, corrosion
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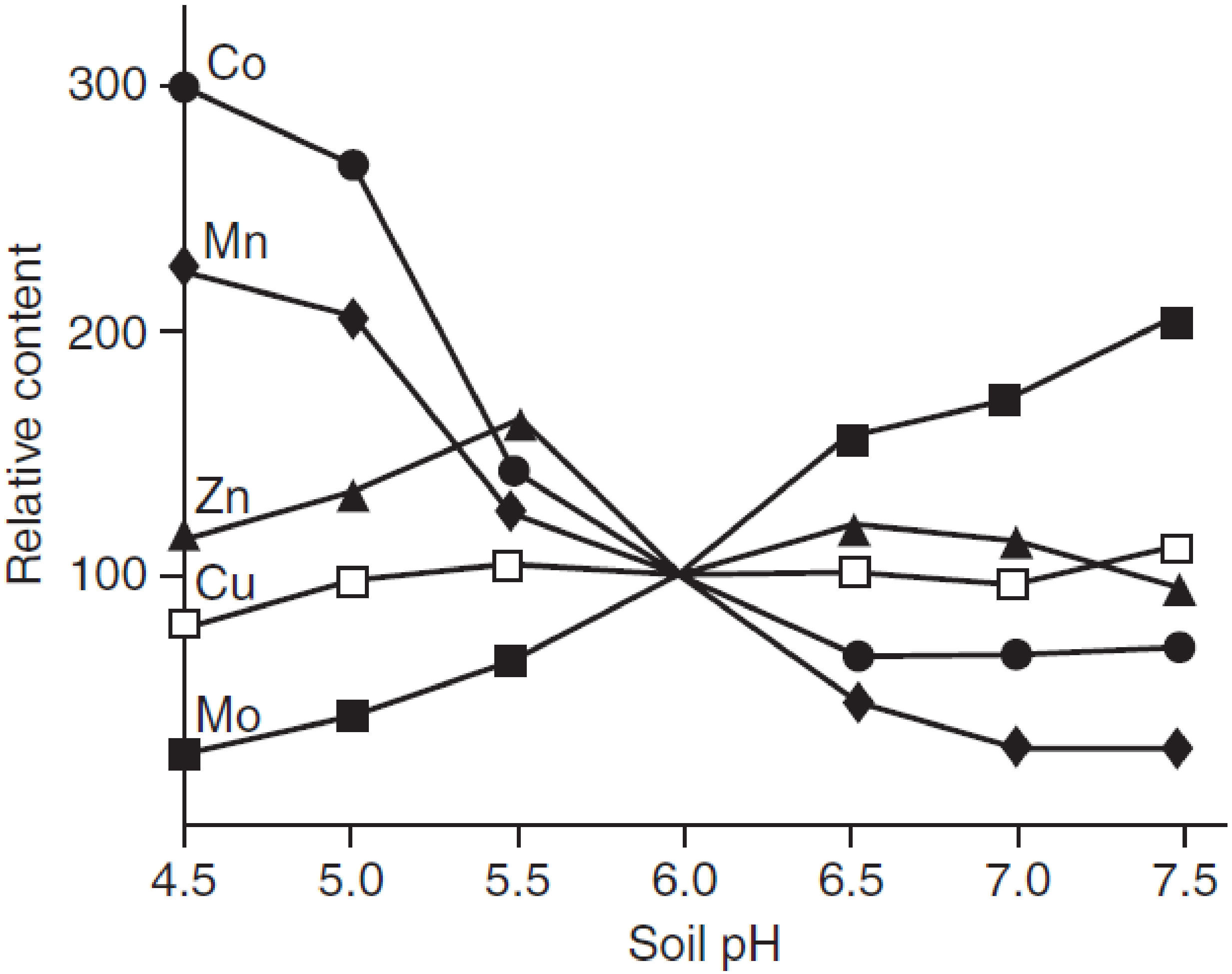
Influence on trace element content of feed

Soil: bedrock for soil formation
pH, ion exchange condition, humus etc.
location and climatic factors

Plant: species, organ, age
botanical composition, time and frequence of utilisation

Harvest conditions
field lay time, soil contamination

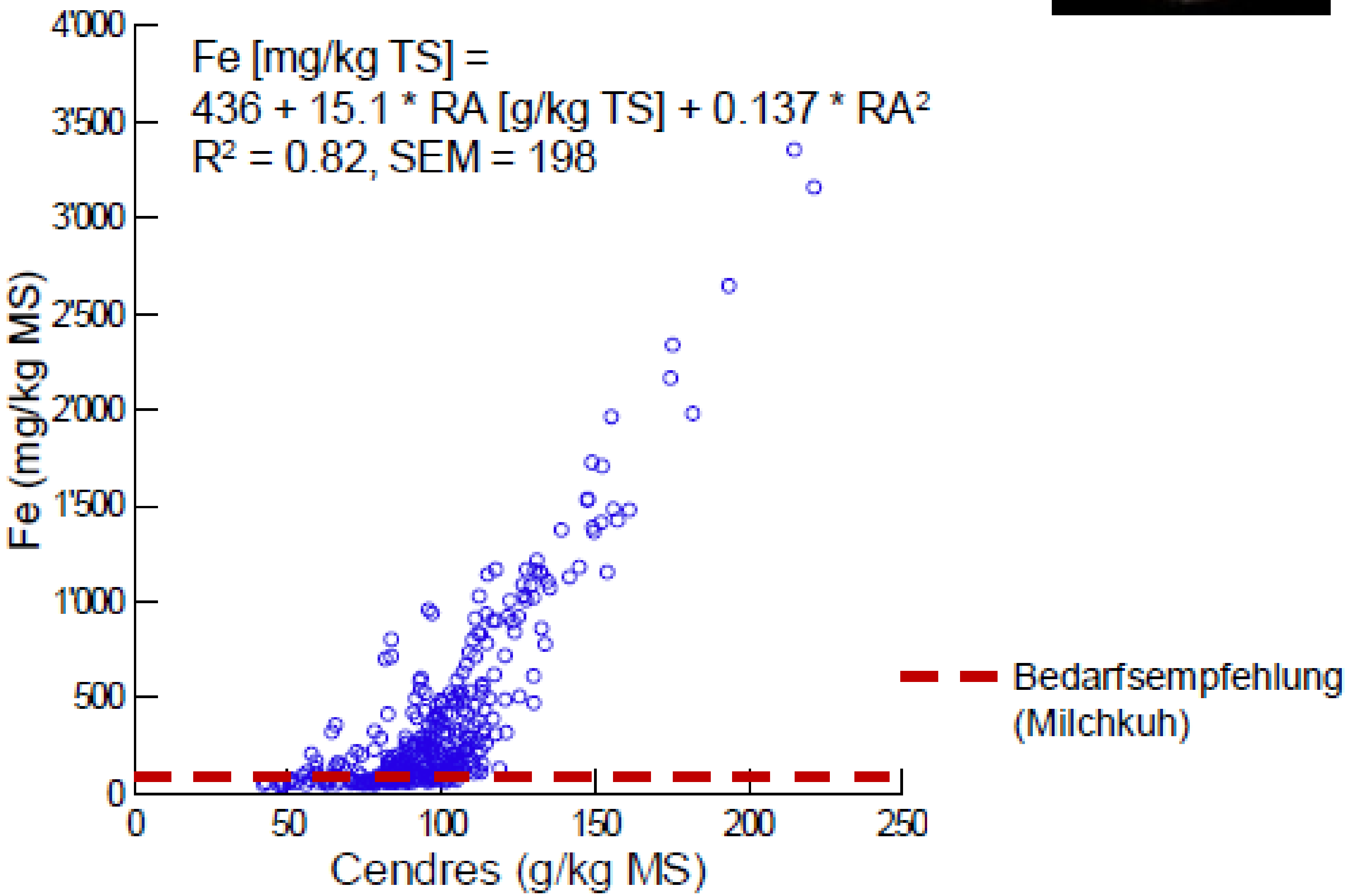
Feed processing
fractionation, contamination
addition of processing aids



Influence of soil pH on trace element uptake in plants (Suttle, 2010)

	1.cut	2. cut	3. cut	4. cut	Recommen-dation
LUFA NW					
Copper	8,9 3,5 – 23,8	9,3 3,1 – 20,9	10,2 5,9 – 25,2		10 (35)
Zinc	43 15 – 426	51 20 - 616	48 28 – 180		50 (150)
Manganese	125 16 – 669	156 24 – 505	152 37 - 457		50 (150)
Iron	619 48 – 7648	594 73 – 4835	613 75 – 5095		50 (750)
LA Chemie					
Copper	8,2 3,8 – 10,4	8,9 3,8 – 11,4	9,8 7,9 – 11,6	9,4 7,6 – 10,7	10
Zinc	30 14 - 47	32 14 - 51	34 28 - 41	36 27 – 43	50
Manganese	85 27 – 216	94 31 – 343	103 57 – 188	110 60 - 207	50

[redacted]

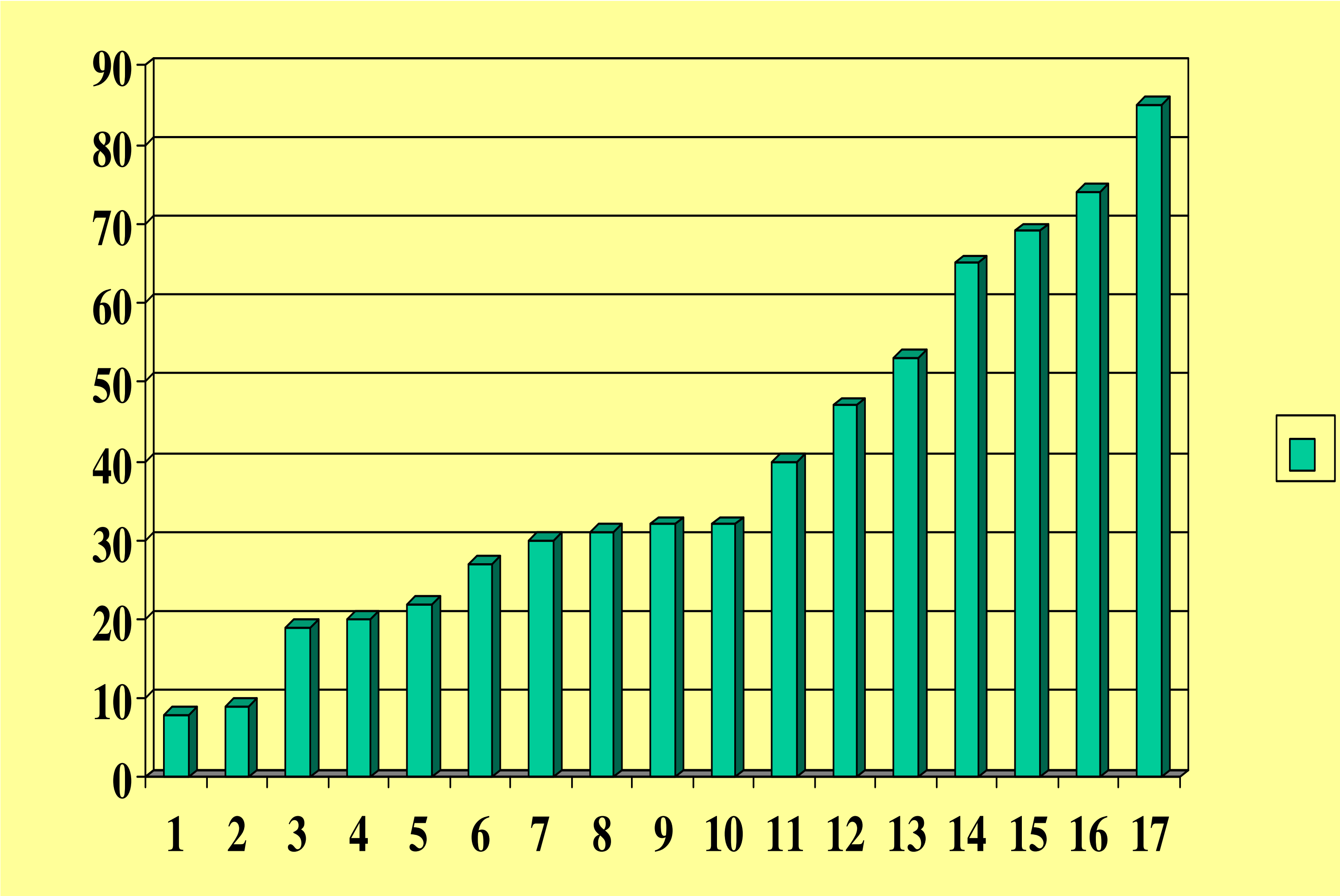


Spurenelemente im Wiesenfutter (Schlegel, 2012)

Distribution of important elements (O`Dell et al., 1972)

Corn kernels					
Fraction	Whole 100	Germ 12	Endosperm 82	Hull 6	
Phytat P %	0,25	1,8	0,01	0,02	
Zn mg/kg	18,8	106	6,66	20,3	
Fe mg/kg	20,9	145	10,7	31,8	
Mn mg/kg	5,2	34,6	2,25	15,8	
Cu mg/kg	1,50	7,28	0,87	7,25	
Wheat kernels					
Fraction	Whole 100	Germ 3,5	Endosperm 70,7	Aleurone 23	Hull 3
Phytat P %	0,32	1,10	0,001	1,16	0
Zn mg/kg	40	222	14,1	119	88,7
Fe mg/kg	54	235	21,5	186	110
Mn mg/kg	56	402	8,80	130	182
Cu mg/kg	4,25	18,5	2,80	12,4	22,6

Zinc concentration in different feedstuffs (mg/kg d.m.)



1 Tapioka
2 Melasse
3 Mais
4 Molkenpulver
5 Luzernegrünm
6 Weizen
7 Gerste
8 B Lupinen
9 Erbsen
10 Palmkern
11 Sojabohnen
12 Sojaextr 44
13 Corn Gluten
14 Rapsextr 34
15 Sonnenblschr
16 Weizenkleie
17 Fischmehl

Processing factor

wheat		mean	Range	Enrichment factor
grain	Zn	35	23 – 56	
	Cu	7	5 – 10	
	Mn	36	28 – 43	
bran	Zn	88	74 – 115	**2,5**
	Cu	14	9 – 30	**2,1**
	Mn	113	100-132	**3,2**

Processing factors

Soy		mean	Range	Enrichment factor
Beans	Zn	44	38 - 57	
	Cu	14	10 – 18	
	Mn	29	24 – 36	
Meal extr.	Zn	54	47 – 61	**1,2**
	Cu	21	15 -36	**1,5**
	Mn	40	28 – 49	**1,4**

Additional paths
Drinking water

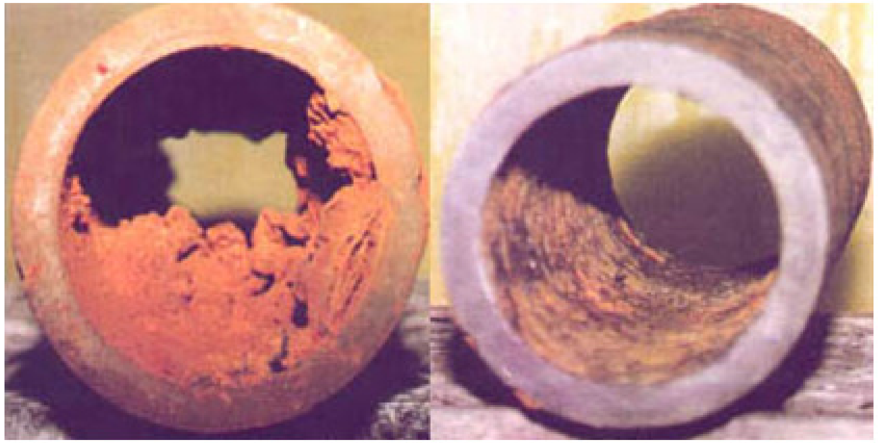
Well water may contain very high concentrations of Fe and Mn.
The oxyhydrates of these elements may clog the pipes and may impair taste (taste) and cause imbalances with other elements.

Element	framework BMELV drinking water livestock	Drinking water ordinance
Iron	< 3 mg/l*	0,2 mg/l
Manganese	< 4 mg/l*	0,05 mg/l

*) Imbalance to other trace elemente, biofilms, clogging pipes and drinking devices

Additional paths
Drinking water

	Median	Range	
Früchtenicht et al. 2000	3 mg/l	0 – 50 mg/l	Germany, 197 samples
Socha et al. 2003 zit nach Genther u. Beede 2013	0,79 mg/l	Bis 123 mg/l	USA (2437 samples)
Osborne, 2006	0,01 – 2,1 mg/l	Bis 30 mg/l	Canada, three different provinces



Aidditional sources:
Drinking water (Effect of increaded iron content drinking water of dairy cows; Genther und Beede, 2013

	0 mg/L Fe	4 mg/L Fe	8 mg/L Fe	SEM	P-value
22 h water intake (L)	60,4	61,9	46,1	4,8	0,05
Behavior duration, s					
Drinking	201	214	124	28,7	0,01
Lapping	196	226	234	84,8	0,65
other	30	28	39	18,8	0,76

Paths

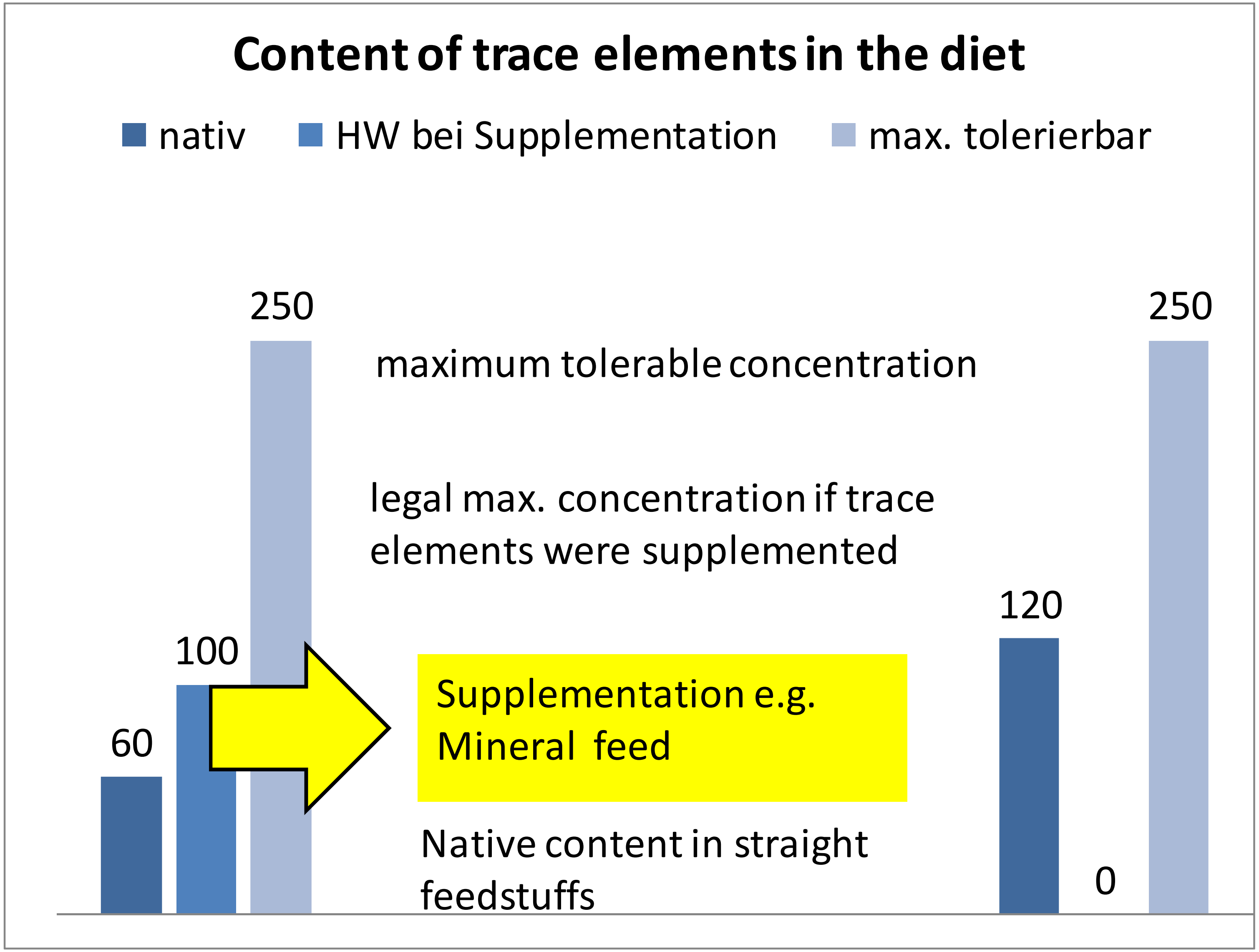
Feed

(straight) feedstuffs
modification by cultivation, harvest, processing etc.

Supplements

Additional paths:

Drinking water
Bedding material
Soil
Abrasion, corrosion
Stable installations
other contact materials


Content of trace elements in the diet
nativ
HW bei Supplementation
max. tolerierbar
250
maximum tolerable concentration
250
legal max. concentration if trace elements were supplemented
120
100
Supplementation e.g. Mineral feed
60
Native content in straight feedstuffs
0

Paths

Feed

(straight) feedstuffs
modification by cultivation, harvest, processing etc.

Supplements → **Mineral feed** → Chemical form, Particle size distribution, galenics

Mineral feed:
- Licking stone
- Paste
- Bolus
- Drench
- Injection

Additional paths:
- Drinking water
- Bedding material
- Soil
- Abrasion, corrosion
- Stable installations
- other contact materials

Trace element supplements

Carbonates (Fe,Co, Cu, Mn, Zn)
Chlorides (Fe, Co, Cu, Mn, Zn)
Oxides (Fe, Cu, Mn, Zn)
Sulfates (Fe, Co, Cu,Mn,Zn)
Hydrogenic phosphate (Mn)
Nitrate (Co)
Fumarates (Fe)
Citrate (Fe)
Lactate (Fe, Zn)
Acetate (Co, Cu, Zn)
Amino acid chelates (Fe, Cu, Mn, Zn)
Glycinate (Fe, Cu, Mn, Zn)
Methionate (Cu) MHA Chelate (Cu,Mn,Zn)
Selenomethionine, Se -Yeast
Jodide, Jodate, Molybdate, Selenate, Selenite

	IT (kg/d)	ICu/d	Cu g/kg T	% ICu
roughages	13,2	95,0	7,2	***21,5***
Concen-trates	8,8	89,8	8,4	***20,4***
Mineral feed	0,15	150	15,1	***34,0***
Soil	1,1	26,4	15,5	***6,0***
Drinking water	80 l	80,0	18,9	***18,1***

22kg dry matter
(60 % roughages/
40 % concentrates)
0,15 kg Mineral feed
5 % soil
80 l drinking water

	IT (kg/d)	ISe/d	Se g/kg T	% ISe
Grobfutter	13,2	1,06	0,08	***14***
Kraftfutter	8,8	0,88	0,08	***12***
Mineral-futter	0,15	4,50	0,29	***61***
Erde	1,1	0,13	0,28	***2***
Tränk-wasser	80 l	0,80	0,32	***11***

22kg
Futtertrockenmasse
(60 % Grobfutter/
40 % Kraftfutter)
0,15 kg Mineralfutter
5 % Erde
80 l Tränkwasser

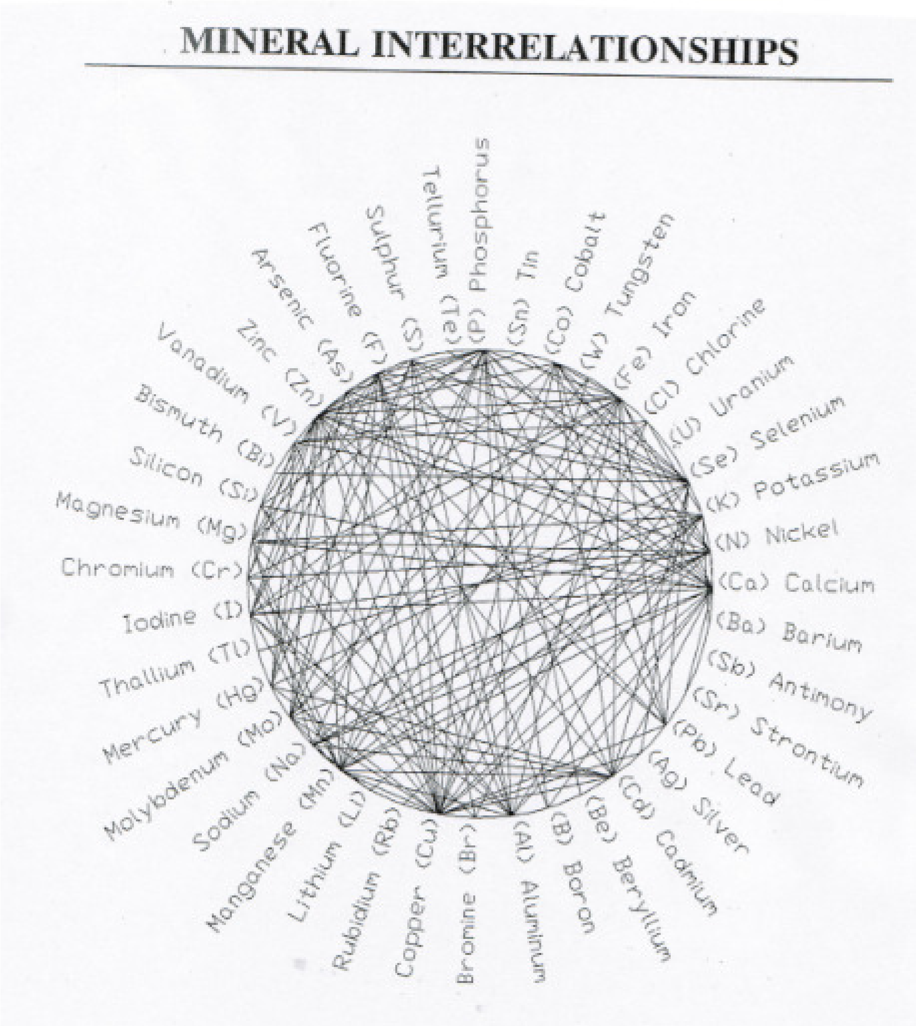
Trace element declaration in mineral feed Company I

Fattening pigs

Element	Mineral feed 1	Mineral feed 2
Cu	500	500
Fe	4000	4000
Zn	3500	3500
Mn	1300	1300
J	60	60
Se	13	13
Organic trace elements	Yes	No
Percentage of diet	3	3

Interrealtionsships

Bioavailability is dependent not only from element concentration and binding form, but also from the relation to other element (ionic radius, valency etc.) and other ligands



Puls, 1994

interrelationships

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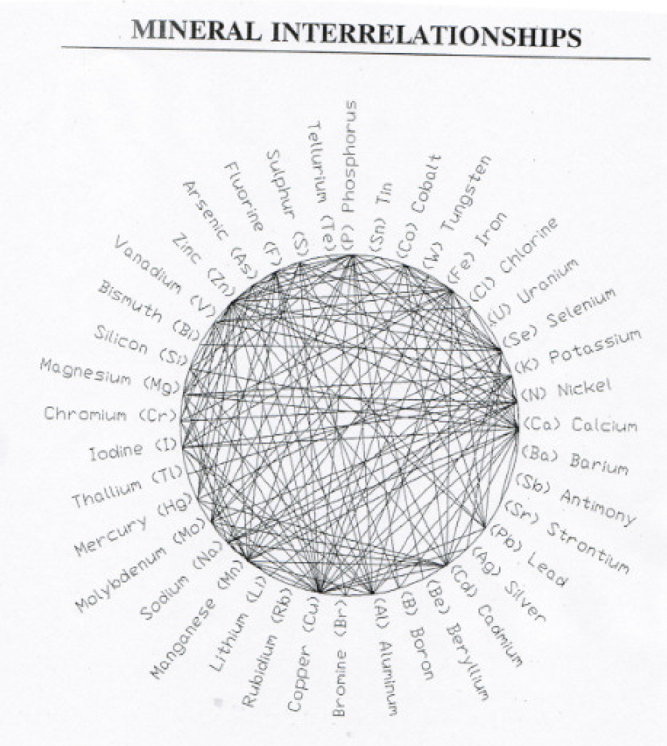

Puls, 1994

Interaction in feeding practice:

Excessiv Zn-intake (e.g. ZnO in E coli Infections) : Cu

High Cu-intake (relevant in young piglets (and calves ?): Fe, Zn, Mn

High Fe- intake (drinking water, soil): Cu, Mn

high S und Mo intake: Cu (ruminats)

High Ca-intake: trace elements (Zn, Mn, Cu)

Bioligands in plant material
Effects on element absorption/utilisation in animals

Phytate	Zn, Fe	Phytase, Fermentation of grains and oil seed residues
Tannins	Fe	
Goitrogens	J	
Fiber	Fe, Cu, Zn, Mn	
Oxalate	Fe	
Nitrite/Nitrate	J	

Factors on trace element availability

Phytase

Feed fermentation

Organic acids

Hydrothermal processes

(probiotics)

→ At an optimal trace element supply element retention in realtion to intake is low

→ Most of the element will be excreted / increase of element concentration in manure (factor 3 – 5)

→ Important for law making:

Soil protection

Fertilizer

Feed

Food

Trace element relation between feed and manure
Dairy cows (Sheppard et al., 2010, 2012)

Element	Manure/Feed ratio	Milk/Feed ratio
Co	3,3	0,0017
Cu	3,4	0,0023
Fe	3,1	0,0059
I	2,4	0,87
Mn	3,2	0,00016
Mo	2,6	0,027
Se	2,1	0,063
Zn	2,9	0,03

Summary

- Trace element intake occurs almost exclusively via feed
- The main part will be apportioned to the native content in feeding stuff and trace element supplements
- The contribution via drinking water and soil intake in most cases was lower than 10 percent of total intake. Other sources contribute significantly only in special cases..
- Supplemented trace elements were normally imported from foreign countries (environmental balance !)