TOMORROW’S CHALLENGES FOR FERTILIZERS AND FERTILIZATION

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No need to carry coals to Newcastle!

Says: the rational use of fertilizers to increase and improve crop yield and quality is indisputable!

Therefore: future research in fertilization and fertilizers shall target on the sustainable use of natural resources!
Rio: the cradle of “Sustainability”

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.

Spaceship Earth:
As a courtesy to your fellow passengers please keep this room in the state as you wish to find it!

From "Our Common Future", The Brundtland Commission, 1987
ISSUES OF (NON) SUSTAINABILITY IN FERTILIZATION:

- Nitrogen compounds pollute atmosphere and water bodies.
- Waste of non-renewable P-resources.
- Charging of soils with heavy metals and radioactivity (P-fertilizers).
- Charging of soils with organic compounds, pharmaceuticals and infectiosity.
Eutrophication of waterbodies

Damage of cultural assets

Negative impacts of diffuse N-pollution
Development of N-balances in Germany

Forecast 2025

Conclusion: severe N-losses without change of strategy are unavoidable and need to be minimized.
Annual average nitrate concentration in groundwater aggregated to different geographical regions of Europe, (mg NO$_3^-$ per l), (1992 - 2009)

Source: Eurostat 2014
Annual diffuse agricultural emissions of nitrogen to freshwater (kg N per ha of total land area), (2009)

Source: Eurostat, 2014
Expected potential increase of overall N-Efficiency by exploitation of advanced measures provided by:

- Agronomy +20%
- Plant breeding +5%
- Fertilizer technology +5%
- Precision Agriculture +10%
- Education, consulting and administration +30%
PRESCRIPTION FOR NITROGEN FERTILIZERS REQUIRED:

the successful “Danish” approach:
“mandatory employment of certified agronomy advisory services leading to farm chemical licensing: limiting mineral N use according to livestock density and crop demands”
ISSUES OF (NON) SUSTAINABILITY IN FERTILIZATION:

Nitrogen compounds pollute atmosphere and water bodies.

Waste of non-renewable P-resources.

Charging of soils with heavy metals and radioactivity (P-fertilizers).

Charging of soils with organic compounds, pharmaceuticals and infectiosity.
PHOSPHORUS FERTILIZERS: “100% / ZERO” APPROACH REQUIRED

Meaning: “Long term complete (100%) utilization of applied P without (ZERO) increasing the content of hazardous components in soils “

The 100% doctrine for P-fertilization:

In a healthy soil a complete utilization of the applied fertilizer can be assumed over infinite times if this P is applied in degradable organic forms or, if of mineral origin, is completely soluble in water or in neutral-ammoniumcitrate and when a soil P level is reached, where P fertilization shows no yield response, further P-fertilization may just replenish what has been removed by harvest products.
ISSUES OF (NON) SUSTAINABILITY IN FERTILIZATION:

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The dark side of P-fertilization!

“Fertilizer“
Lithography by Andreas Paul Weber, 1964

Mineral P-fertilizers contain on an average 259 mg Uran per kg P₂O₅
Table 2: Average annual loads of As, B, Cu, Cd, Ni, Mo, Pb, U and Zn through mineral P-fertilization, its contribution to soil background concentrations and a schematic display of the susceptibility of to plant uptake and leaching.

<table>
<thead>
<tr>
<th>Element</th>
<th>Average annual load (t/ha) through P fertilizers</th>
<th>% of background derived from P fertilization</th>
<th>Susceptibility to plant uptake</th>
<th>Susceptibility to leaching</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO₃</td>
<td></td>
<td></td>
<td>Very high</td>
<td>Very high</td>
</tr>
<tr>
<td>B</td>
<td>1575</td>
<td></td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Zn</td>
<td>604</td>
<td>1.42</td>
<td>High</td>
<td>Medium</td>
</tr>
<tr>
<td>Cd</td>
<td>76</td>
<td>34.0</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Cu</td>
<td>170</td>
<td>2.00</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Mo</td>
<td>50</td>
<td>11.5</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>Ni</td>
<td>71</td>
<td>0.60</td>
<td>Low</td>
<td>Medium</td>
</tr>
<tr>
<td>Pb</td>
<td>14</td>
<td>0.06</td>
<td>Very low</td>
<td>High</td>
</tr>
<tr>
<td>As</td>
<td>38</td>
<td>4.50</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>U</td>
<td>239</td>
<td>18.0</td>
<td>very low</td>
<td>High</td>
</tr>
</tbody>
</table>
Based on P-fertilizer sales statistics; until 1990 only West Germany, from 1990 including „neue Länder“, calculation without basic slag phosphates from steelworks (Thomasphosphates)

13,333 t U
or 1 kg/ha U
or expected increase of U in topsoils: + 0.32 mg/kg U

Uranium applied to German agricultural land by P-fertilizers
Proposed action to protect soils and water bodies from fertilizer-derived uranium by the German Commission for Soil Protection:
(values are similar to the proposed EU regulation for Cd!)

Limit the input of U to soils by fertilization through regulation of U in mineral P fertilizers to 1 g/ha*a U at GAP*:

**Fertilizers with < 5% P$_2$O$_5$:**
- Limit for declaration: 1 mg U per kg fresh material
- Limit for trading: 1.5 mg U per kg fresh material

**Fertilizers with > 5% P$_2$O$_5$:**
- Limit for declaration: 20 mg U per kg P$_2$O$_5$
- Limit for trading: 50 mg U per kg P$_2$O$_5$

* GAP: Good Agricultural Practice = 50 kg/ha*a P$_2$O$_5$
On an average during the last 10 years in Germany alone 167 T uranium were spend every year with mineral P-fertilizers....
... which contained enough energy to supply 2,350,000 average sized German households and equals the energy of firewood harvested from 5,600,000 ha forest.
From 10 g U (corresponding to a P-fertilization of 22 kg/ha P according to GAP) 500 kW of energy can be produced. Compared to the same amount of energy derived from coal this saves a total of 500 kg CO₂. At a CO₂–tax of 0.08 €/kg this equals a value of 40 €/ha.

The monetary value of 10 g U (as yellow cake) amounts actually (28.1.2010) 1.11 €, the costs of the 22 kg P 32 €.
Uranium in world P-resources can feed the nuclear energy cycle for 350 years

Cleaner fertilizers
Cleaner soils
Cleaner waters
Cleaner atmosphere
Increased profitability of fertilizer manufacturing

(source: Haneklaus et al., 2015)

(World U resources actually last for about 50 more years)
But there are more hidden treasures in Rock-Phosphates:
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Charging of soils with organic compounds, pharmaceuticals and infectiosity.
Organic toxic compounds in sewage sludges, composts, meat-bone-blood meals (MBBM) and digestates

HCB, γ-HCH, DDT and metabolites, aromatic halogenated hydrocarbons, dichlorbenzol (1.4-DiCB), decambromdiphenylether (DBDE), phenoles and chlorophenoles acc. EPA, pentachlorphenole (PCP), aliphatric halogenated (polychlorinated) hydrocarbons, chlorparaffine, adsorbed halogenes (AOX), halogenated hydrocarbons (incl. trichloethene, dichloethane, trichloethane, chloroforme, tetra), phthalates (total), di(2-ethylhexyl)phthalat (DEHP), tensides (total), alkylbenzylsulfonates (LAS), nonylphenol, organotin derivates, tributyltin, polychlorinated biphenyles, PCB´s No: 28, 52, 101, 138, 153, 180, terphenyles, chlophen A40 + A60, PCDD/PCDF (total), polycyclic aromatic hydrocarbons (PAH/PAK), benz(α)pyrene, benzole, tuluole, xylole, BTX (total), mineral oils

EDC endocrine disrupting chemicals: p-nonylphenole, bisphenole
Pharmaceuticals and their metabolites (e.g. antibiotics)
Infectiosity (viruses (e.g. foot & mouth), bacteria (e.g. EHEC), prions (e.g. BSE))
(not to forget the “inorganics: As, Cd, Co, Cr, Cu, Hg, Ni, Pb, Sb, V, U, Zn!)

Conclusion: strictly NO sewage sludges, composts, MBBM and digestates on agricultural land without complete (mono-) incineration for P-recovery!
PRECISION AGRICULTURE – TWILIGHT OF THE GODS OF TECHNOLOGY
16th World Fertilizer Congress of CIEC
Technological innovation for a sustainable tropical agriculture
Rio de Janeiro, Brazil (20-24 October 2014)

FERTILIZATION IN PRECISION AGRICULTURE – TWILIGHTH OF THE GODS OF TECHNOLOGY

1991

Local Resource
Farm chemicals
Fertilizers
Slurries & Sludges

Management
Combine
with yield monitor

Application
Information
Interpretation
Planning

Result

Institute of Plant Nutrition and Soil Science

2005

PRECISION AGRICULTURE

INFORMATIONS - BESCHAFFUNG

INFORMATIONEN - BESCHAFFUNG

TECHNOLOGIE

Daten-Management & Interpretation
After 30 years: GPS is still a freak technology in agriculture but fully implemented in civil and military technology.
WHY? Remember!

Expected potential increase of overall N-Efficiency by exploitation of advanced measures provided by:

- Agronomy +20%
- Plant breeding +5%
- Fertilizer technology +5%
- Precision Agriculture +10%
- Education, consulting and administration +30%
No cost-effectiveness!

Expected savings through application of Precision Agriculture

<table>
<thead>
<tr>
<th>Source of costs</th>
<th>expected savings</th>
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<tbody>
<tr>
<td></td>
<td>(€ per annum per 500 ha farm size)</td>
</tr>
<tr>
<td>Fertilizers</td>
<td>-10% 1.500,-</td>
</tr>
<tr>
<td>Pesticides</td>
<td>Technology not legally approved</td>
</tr>
<tr>
<td>Salaries (machinery op.)</td>
<td>-100% 50.000,-</td>
</tr>
</tbody>
</table>

Additional benefits through prolonged machinery operation time possible.
Conclusion: profitable implementation requires autonomous field machinery, the costs of the “last” man replaced pays for the technology; costs benefits from increasing yields and saving farm chemicals are simply windfall gains.

Autonomous Vehicles

GPS assisted robots train racing camels in the Emirates
When the last man leaves the field ..... 

..... Precision Agriculture may arise!?

Thank you for your attention!