Pharmaceuticals in Soil, Sludge and Slurry
Conclusions and perspectives

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Unit IV 2.2 - Pharmaceuticals, Washing and cleansing agents

Federal Environment Agency of Germany

Umwelt Bundes Amt

Für Mensch und Umwelt

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Topics and conclusions of the first day
Prof. Dr. Gerd Hamscher – Justus Liebig-University Giessen

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There are still a lot of open questions …

- **Do we really know all routes of entry for veterinary drugs into the environment?**
- **Is it really possible to identify and / or synthesise environmentally sound pharmaceuticals without the loss of therapeutic efficacy?**
- **What does „environmentally sound“ imply? - After therapeutic use, a drug is metabolized to a biologically inactive or non-toxic product (= elimination)**

  - In the case of antibiotics this means loss of antimicrobial activity

… meanwhile: reduce the entry

- Healthy animals need less treatment
- Prudent use of antibiotics
- Fermentation or other treatment of liquid manure
- Knowledge transfer to veterinarians, farmers and students

Topics and conclusions of the first day
Prof. Dr. Benny Chefetz – The Hebrew University of Jerusalem

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- PPCPs are present in reclaimed wastewater used as irrigation water
  - → PPCPs are introduced into agricultural soils
  - → some PPCPs tend to retain in the top soil layer
  - → some PPCPs can be taken up by crops.

- Can PPCPs enter the food-chain!?; What are the risks (health) associated with that?
- Risk assessment for mixture of chemicals!
- Is there a need for new regulations for water quality (irrigation water)?

Topics and conclusions of the first day

Prof. Dr. Sören Thiele-Bruhn, University of Trier, Germany

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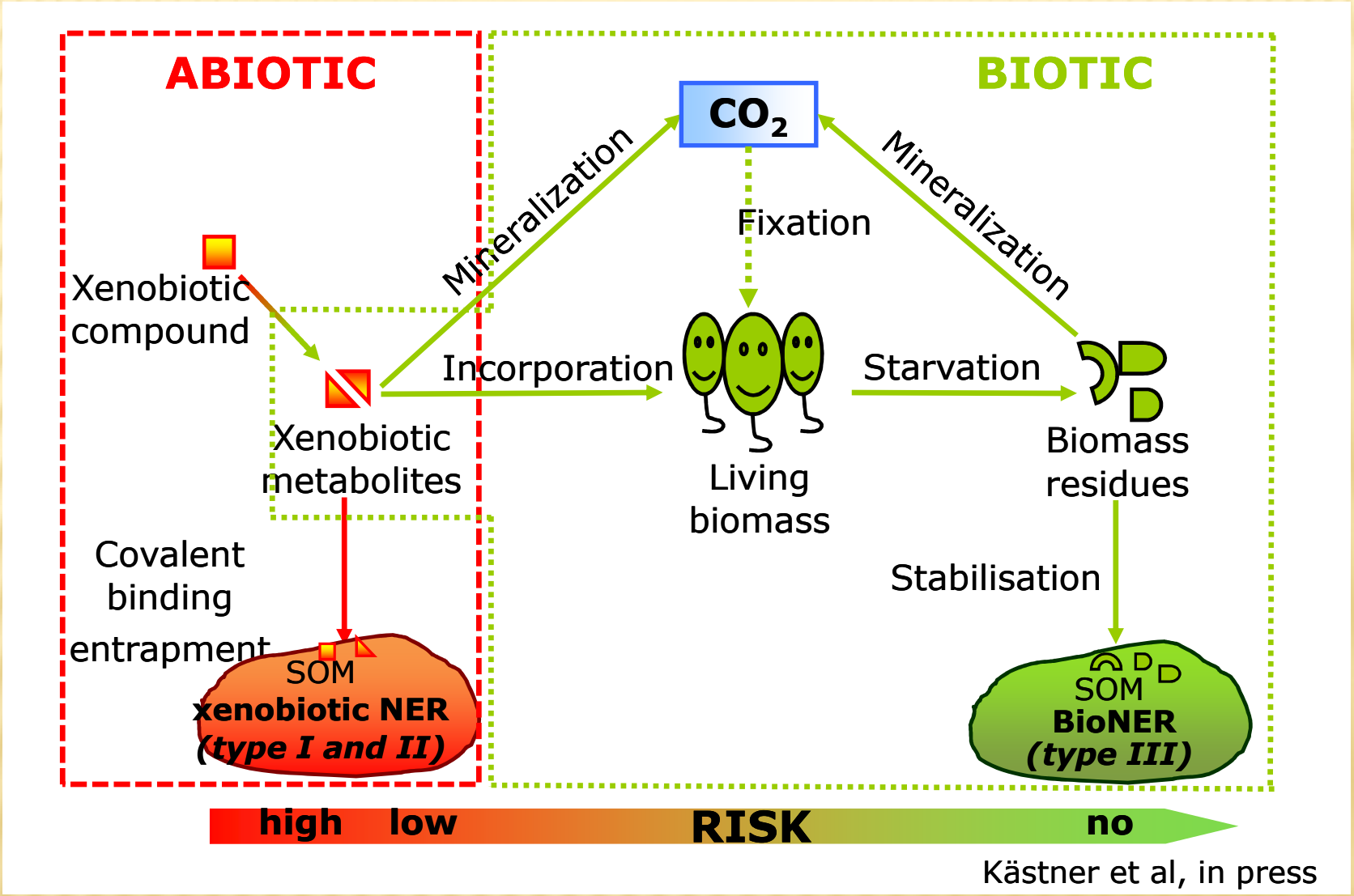
- **Antibiotics** reach the soil environment via excrements in **considerable amounts**.
- Antibiotic medication **alters the molecular and microbial composition** of excreta.
- Mid- to long-term effects of antibiotics and **manure interact** and **manure borne microorganisms** may survive in soil on a mid-term.
- Effects on **functional** and **structural** diversity of soil microorganisms.
- Tests on biodiversity are more sensitive than **single endpoint tests**.
- Structural community shifts may be accompanied by **functional redundancy** **Community structure is a more sensitive parameter.**
- Long-term effects occur → **apparent concentration independence**.
- Accumulation and effects are different in **soil microcompartments**.

Topics and conclusions of the first day
Dr. Karolina Nowak from UfZ Leipzig /RWTH Aachen



Future plans: New risk assessment including bioNER formation

Topics and conclusions of the first day
Prof. Dr. Annette Eschenbach University of Hamburg

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Need for systematic scientific studies to clarify open questions and to enable a validation of the specific methods proposed in the sequential extraction scheme

- Development of more simple procedures or quantification by calculating the difference (e.g. irreversible binding)
- Studies on consideration of soils with different properties, their variability and different genesis; climate and land use change; realistic simulation of environmental conditions

Topics and conclusions of the first day
Dr. Heike Schmitt – University Utrecht

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Evidence for occurrence of resistance in the environment

- Detectable by culturing / genetic methods

Role of antibiotic residues?

- In principle, yes
- At environmentally realistic concentrations?

Why are we concerned?

- Public health as protection goal
- Evidence for public health relevance?

Regulatory needs

- **Placing in risk assessment framework: role of antibiotic residues?**
- **Test systems?**

Topics and conclusions of the first day
Dr. Nadine Tauchnitz – University Leipzig

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High probability that mixtures of different veterinary drug components may occur in manured soils

PECmix/soil up to more than 1000 µg/L

High demand for further research!!!!

Topics and conclusions of the first day
Inke Reimer – BVL

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Substance volumes sales in Germany 2011

Tetracyclines	576 t
Aminopenicillins	505 t
Makrolids	185 t
Sulfonamids	185 t

Further need for reduction!!!!!

Summary Fate and Effects for prioritized PhCs for sewage sludge monitoring

Sabine Konradi, Federal Environment Agency of Germany

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Therapeutic group	Compounds	Occurrence in sludge	Fate in Sewage treatment plant and soil	Terrestrial Ecotoxicity
Antibiotics	Ciprofloxacin, Sulfamethoxazole	>500µg/kg TS in sludge	**Very high sorption STP** **very low degradation STP** Very slightly mobile – Immobile in soil	Very toxic to Microbs EC50 < 1mg/kg
Psychiatric drugs	Carbamazepine	>500µg/kg TS in sludge	Very Low sorption STP **no degradation STP** Very slightly mobile in soil	Harmful to Microbs EC50 10- 100mg/kg
Analgesics	Diclofenac	100—500 µg/kg TS in sludge	Low sorption no degradation STP Very slightly mobile in soil	Toxic to Microbs EC50 1- 10mg/kg
Beta-blocker	Metoprolol	50—100 µg/kg TS in sludge	Very Low sorption STP **no degradation** Very slightly mobile	Very toxic to Microbs EC50 < 1mg/kg
Lipid regulator	Fenofibrate	50—100 µg/kg TS in sludge	High sorption Very low degradation low mobility in soil	Slightly toxic to Microbs EC50 100- 1000mg/kg

Topics and conclusions of the second day

Jean-Pierre Lumaret - Université Montpellier III, France

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- **Canada**
  - Slowdown in the degradation rate of dung associated with the reduction of insect activity
  - Direct addition of ivermectin to dung (spiked dung) at concentration equivalent to the levels observed in dung of treated animals:
    - droppings little degraded after 340 days of exposure
    - control dung extensively degraded after 80 days

Floate, *Bull. Entomol. Res*. 88 (1998) 25-35

- **Australia**
  - A field study confirms these findings

Dadour, Cook, Neesam, *Bull. Entomol. Res*. 89 (1999) 119-123

The use of certain chemicals may indirectly affect vertebrates by reducing their **food resources**.This applies to many **birds**, some **bats** (Greater Horseshoe Bat, Serotine, Noctules) that feed on dung beetles and Diptera (Bat News, 50, 1998) and various mammals like **hedgehogs**, **moles**, **shrews** and **badgers** whose diet includes many invertebrates.

Topics and conclusions of the second day
Prof. Dr. Alistair Boxall, The University of York, Great Britain

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- Knowledge about uptake is essential for effective risk assessment of pharmaceuticals and personal care products
- Chemistry of the environment can be very important
- What happens in one organism doesn't necessarily happen in another
- Uptake might be predictable but we need to know much more about effects of species traits

Topics and conclusions of the second day

Dr. Annegret Hembrock-Heger, LANUV NRW, Germany

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- By application of slurry to agricultural land in amounts usually used in agricultural practice veterinary pharmaceuticals can be found in soils.
- In slurry tetracyclines, sulphonamides and fluoroquinolones were detected, while in soils only tetracyclines were found.
- The concentrations of tetracyclines in soils are below the threshold limit value of 100 µg/kg (EMEA/VICH phase I).
- Repeated application of slurry leads to enrichment of veterinary pharmaceuticals in soils.
- In groundwater tetracyclines and fluoroquinolones were not found.
- The application of slurry to agricultural land in amounts usually used in agricultural practice does not yet lead to a relevant input into groundwater.
- In vegetables tetracyclines, sulphonamides and fluoroquinolones could not be detected.
- Due to the antibiotic effects of these compounds the input into soils should be minimized to avoid spreading of antibiotic resistance.

Topics and conclusions of the second day

Dr. Evelin Ullrich & Christiane Reuschel, SMUL, Saxony, Germany

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- 27 cattle farms and 16 pig farms were classified by **size and performance categories**.
  ESBL and/or MRSA were detected in **77 %** of the farms or farm divisions.
- Slurry manures and fermentation residues:
  The selected antibiotics could be detected in 28% of the cattle manures/fermentation residues and in 93% of the pig manures/fermentation residues.
- Soils:
  In total 16 out of 40 analysed soil samples showed the presence of tetracycline, chlortetracycline, doxycycline, tiamulin.
  All except 4 results were below the limit of quantification.
  Maximum level: 25 µg/kg/OS doxycycline
- Water and plants
  None of the analysed active substances were detected in any of the water or plant samples.

Topics and conclusions of the second day

Anja Töpper, Center for Agricultural Technology (LTZ) Augustenberg, Germany

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Main findings:

- no entry of tetracycline and enrofloxacin into barley, wheat and corn under practical conditions
- soil: no detectable concentrations of these two antibiotics under realistic conditions
- no significant growth differences in various plants after administration of antibiotics

Topics and conclusions of the second day

Prof. Dr. Monika Krüger – University of Leipzig, Germany

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- Application of fermented herbal extract leads to reduction of harmful gases, dust and microbial pollutions in chicken broiler pens.
- Simultaneously the endotoxin concentration of the air was significantly reduced.
- Cold fogging and water application of Fermented Herbal Extract is suitable to reduce the burden of animals and their farmers inside the pens but the emissions too.
- Oral application of charcoal, Sauerkraut juice and humic acids influence the C. botulinum antibody levels indicating reduced gastrointestinal neurotoxin burden. Omitting of these substituts led to increased antibody levels. Charcoal, sauerkraut and humic acids are old but still good strategies to control the homeostasis in the gastrointestinal tract of dairy cows.

Conclusions of the workshop - 1

What`s the situation concerning pharmaceuticals in soil, sludge and slurry at present?

- Pharmaceutical residues can persist and accumulate in soil over long time
- There is evidence of an uptake of pharmaceuticals in plants and soil organisms like earthworms and evidence that pharmaceutical residues like antibiotics may lead to changes in the micro-soil-structure
- Livestock excrements that contain residues of antiparasitics defenitely pose a danger for dung organisms provoking lower degradation rates
- Evidence that antibiotics in soil can further select resistance
- At present there is no regulation concerning pharmaceuticals in sludge, slurry or soil and no monitoring after marketing authorisation of pharmaceutical products

Conclusions of the workshop - 2

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What are the most important fields for further research?

- Establishment of nationwide and European monitoring programs for more reliable data of pharmaceutical concentrations in soil, sludge and slurry
- Antibiotic resistance - placing in risk assessment framework: role of antibiotic residues, definition of trigger/precautionary levels
- Assessment of mixture toxicity to get a more realistic picture of the impact of the practice mix of pharmaceuticals together with other chemicals on soil organisms
- Identification and assessment of active metabolites of pharmaceutical substances
- Fate of pharmaceutical substances in fermentation processes
- Long-term effects of sublethal dosis of pharmaceuticals on soil organisms
- Monography system – public available data

Conclusions of the workshop - 3

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What can be done to improve the situation?

- Initiation of European-wide projects to characterise the status quo of pharmaceuticals occurence in soil, sludge and slurry, provide public-available information about properties, fate and toxicity of pharmaceuticals (monography system) and to develop environmental quality standards and concerned actions
- Strategies for the reduction of medication in animal husbandry also looking to better hygiene and livestock breeding conditions
- Establishment of more effective procedures to reduce pharmaceutical load of sewage sludge
- Development of environmentally sound pharmaceuticals

- And for scientists: stay in contact!!!

Pharmaceuticals in Soil, Sludge and Slurry

Thank you very much for your attention!