Available technologies and strategies for nutrient and energy recovery

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Available technologies and strategies for nutrient and energy recovery

• The challenges
• Principal options of manure management
• Key aspects of livestock production respecting the environment
• Crucial issues
• Technology available to support sustainable manure management
• Current situation, case studies Europe and arising countries (Asia)
• Personal conclusions
The challenges

• The quantitatively most important product of livestock is excreta (urine, feces)
  – e.g. 1 fattening pig = 100 kg animal, 300-600 kg excreta

• Livestock excrete 60-95% of the nutrients taken up in feed (N – nitrogen, P – phosphorous etc.)

• Livestock waste can have serious environmental impacts
  – Surface water pollution (nutrients, org. matter) → eutrophication (incl. marine ecosystems)
  – Groundwater pollution (nitrate)
  – Pathogens (spread via water)
  – Emissions to atmosphere (ammonia, methane, nitrous oxide etc.)

→ Livestock waste has to be handled in a way that does not harm the environment
Principal options for handling manure

1. Recycling as fertilizer on crops (or feed)
   - Energy recovery possible

2. Manure treatment to remove substances with environmental relevance
   - Organic substance and N can be degraded
   - Minerals/heavy metals must be taken out of system to alternative use or proper disposal
   - Energy recovery possible by anaerobic digestion

3. Uncontrolled release to the environment
   - Proper manure management is crucial
     - Costly
     - Harm to environment only prevented if facilities are properly dimensioned and fully functioning
     - Nutrients are wasted, especially N (fossil fuel) and P (limited resource)
   - Not acceptable for environment reasons
Which options are appropriate?

- Existing farms in area with lacking potential for recycling: Treatment is often the only solution
  - Can it really meet environmental limits (discharge standards)?
  - Is it economically bearable?

- Existing farms in area with potential for recycling: Recycling will usually be cheaper and safer than treatment

- New farms: In most cases economically beneficial to choose farm location according to manure recycling potential in the vicinity

- Combination of treatment (e.g. biogas and recycling) can be appropriate if the treatment brings special benefit (e.g. electricity for EVAP-system)

→ Zero discharge must be the aim!
Key aspects of livestock production respecting the environment

• No discharge of waste/effluents to surface waters
  – All excreta must be collected and managed

• Land livestock balance (for manure recycling)
  – Sufficient land (own or neighbouring with manure contract) for recycling (balance between nutrients in manure and crop requirements)
  – In ruminant systems: Livestock numbers not surpassing roughage supply
  – Livestock production based on concentrate: in areas with crop production
  – In areas with land livestock imbalance: Minimise nutrient excretion and reduce livestock numbers

• Good manure management
  – Manure used only according to crop nutrient requirements (time and dose)
  – No serious environmental impacts (run-off/overflow, excessive doses etc.)
  – Low emission techniques: manure treatment if necessary
Key aspects of livestock production respecting the environment (2)

• No risk for human and animal health
  – No introduction of pathogens into drinking water resources and food chain
  – No introduction of antibiotics and pharmaceutical substances to the environment → careful use of such substances
  – must be recycled on land or treated to meet discharge standards
  – Prevention of zoonotic diseases

• No harm to soil fertility
  – No heavy metal accumulation (restrictive use of heavy metals)
  – No excessive doses of manure on land

• Respecting the quality of live of (non-agricultural) population
  – Prevention of odour and fly nuisance near settlement areas

• Manure treatment to improve manure characteristics or achieve special benefit (biogas, compost et.)
Crucial issues

- Especially specialized pig and poultry production face problem with nutrient surplus (no local link to land)
- Manure treatment alone does not usually solve the problem (or only at very high cost) → remaining nutrients have to be removed
- Water use in animal housing must be minimized to reduce slurry volume (high cost for storage and application)
- For large specialized livestock farms (especially pigs and poultry) and in areas with high livestock density the transport distance (costs) to the crop site is quickly a limiting issue
- If manure has to be transported over large distances, as much as possible solid manure should be produced
Technology available to support manure management with low environmental impact

- Livestock housing systems
  - Slurry housing systems (all excreta collected in slurry; fully or partly slatted)
  - Slurry/solid manure housing systems (slurry and solid manure produced)
  - Solid manure systems (only possible with sufficient litter)
  - Special low emission (NH\textsubscript{3}) housing systems
  - Optimized ventilation techniques, EVAP cooling, thermal insulation
  - Air scrubbing (biofilters, chemical scrubbers)

- Manure storage
  - Concrete or metal tanks (preferentially covered)
  - Covered lagoon (with liner floor to prevent leaching losses)
  - Covered solid manure stores
Technology available to support manure management with low environmental impact

• **Manure treatment**
  – Physical separation (slurry $\rightarrow$ solid and liquid fraction; filtration, centrifugation)
  – Anaerobic digestion $\rightarrow$ biogas (benefit depends on potential for electricity use)
  – Aerobic treatment (reduces organic substance and N content)
  – Composting $\rightarrow$ compost
  – Drying of solid manure
  – Etc.

• **Manure application**
  – Conventional low cost equipment for transport
  – Slurry tanks (transport and spreading) for tractors or self-propelled
  – Low NH$_3$ emission spreading techniques (trailing hoses, trailing shoe, injection)
  – Solid manure spreaders
Other actions to support manure management with low environmental impact

• Feeding
  – Ration content well adapted to animal requirements
  – Rations with reduced protein content for pigs and poultry (with use of pure amino acids)
  – Rations with reduced P content for pigs and poultry (with use of phytase)
  – Reducing heavy metal content of feed to minimal requirements of the animals

• Water use
  – High pressure equipment for cleaning in animal houses
  – No cooling of animals by sprinkling water
  – Covered slurry tanks to reduce rainwater
Current situation: Europe

• Zero discharge is standard
• Manure management highly variable (different housing, feeding and manure handling systems, climatic and structural conditions, tradition etc.)
• High proportion of liquid manure; slurry mostly stored in tanks
• Utilization of the manure on the same farm as it is produced is still most common, especially for slurry
  – Slurry transport to other farms/areas if legally required (e.g. Netherlands)
  – Enforced legislation on nutrient balance mainly in Switzerland, Denmark, Netherlands
• Most countries have guidelines about minimal period of storage for manure
• Special treatment rather uncommon
Current situation: Arising and developing countries

- Rapid growth of livestock production (especially in Asia and Latin America), predominantly of intensive sector
- concentration close to urban centres
- shift from ruminants to monogastrics
- large and specialized units with little or no land
- discharge of manure to surface water is common
- gaining importance of slurry based systems (often slurry not utilized)
- Often inappropriate manure management practice and infrastructure

→ Water pollution originating from livestock production
→ Nutrient and heavy metal overloads on agricultural land

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Case study: SE-Asia

• Large structural variability, e.g.
  – Thailand: majority of pigs on medium/large farms (>1000 pigs), mostly intensive
  – China: Both very large farms and backyard production
  – Vietnam majority of pigs on very small farms, but rather intensive
  – Cambodia, Laos: intensive only emerging
→ large variability in management

• Solid manure usually recycled (market demand)
• Liquid waste seldom recycled → discharge or other release to the environment
→ major source of pollution
• Fast increasing awareness
→ measures are introduced
Personal conclusions

• **Zero discharge is possible**, but it takes:
  – Awareness of the problem
  – Legal action
  – Appropriate technology
  – Considerable investment

• The basic knowledge on good manure management technique is available, but
  – It has to be adapted to the specific situation
  – It takes time to introduce it in regions with no “tradition” (esp. for slurry)

• Manure recycling = geographically spread
• Liquid manure is a bigger problem than solid manure
• Intensive livestock production causes larger environmental impact than extensive, but extensive production can also cause serious problems
Thank you for your attention