



Ministry of Economic Affairs,
Agriculture and Innovation

Workshop

Managing livestock manure for sustainable agriculture

24-25 November 2010,

Wageningen, The Netherlands

European Commission, DG Environment
Ministry of Economic Affairs, Agriculture and Innovation of the Netherlands

Contents

Introduction	5
Programme	7
Summary and conclusions	9
Summary parallel workshop sessions	11
I. Environmental performances of manure processing techniques.....	11
II. Economic feasibility of manure treatment.....	14
III. Treated manure as mineral fertilizer	15
IV. Strategies to increase nutrient use efficiency of manures.....	17
V. Manure & co-digestion for energy recovery	19
Abstracts of oral presentations.....	21
Manure Treatment: Best Available Techniques (BAT)	23
Manure treatment technologies which reduce nutrient leaching from pig production in Baltic sea region	24
Influence of anaerobic digestion of animal manures and energy crops on the fertilizer value of digestates.....	25
Manure management in Poland.....	26
Small scale manure processing in France Brittany.....	27
Manure treatment technologies: On farm versus centralized strategies. NE. Spain case study.....	29
Sustainable Use of Phosphorus.....	30
Managing phosphorus cycling in agriculture; a review of options for the Netherlands.....	31
Strategies to increase nutrient use efficiency of manures	32
Biological nutrient removal and ammonia air stripping: full scale plants and experimental trials in Italy	33
Abstracts of posters	35
List of participants	65

Introduction

Livestock production systems have various effects on the environment. Most of these effects are related to emissions of nitrogen and phosphorus from manures to the environment. The Nitrates Directive aims to protect water quality across Europe by preventing nitrates from agricultural sources polluting ground and surface waters and by promoting the use of good farming practices.

Improvement of management of manure is a major option to decrease nitrogen and phosphorus emissions to the environment. Moreover, manure processing could help Member States of the European Union in controlling manure surpluses and may help in better implementation of the Nitrates Directive.

The European Commission DG Environment and the Ministry of Economic Affairs, Agriculture and Innovation of the Netherlands organize the workshop ***Managing livestock manure for sustainable agriculture*** on November 24 and 25 in Wageningen, The Netherlands.

The aim of this workshop is to promote exchange of information on manure management among Member States, with special focus on manure processing. The target audience of this workshop are policy makers, farmer organizations, environmental groups and scientists.

The workshop includes plenary sessions with invited speakers, visits to manure treatment installations and farms with improved manure management, and workshop sessions.

DG Environment
Ministry of Economic Affairs, Agriculture and Innovation

Programme

Wednesday 24 November

8.00 h	Registration	
	Plenary session (Chair: C.. Oomen, Ministry of Economic Affairs, Agriculture and Innovation)	
9.30 h	Opening	C. Oomen, Ministry of Economic Affairs, Agriculture and Innovation
9.45 h	Opening	M. Hamell, DG ENV
10.00 h	Nitrates Directive and manure management	J. Casaer, DG ENV
10.15 h	Pilot Mineral concentrates as fertilizers in the Netherlands	E. Mulleneers, Ministry EA & I
10.30 h	Break & Posters	
11.00 h	Manure Treatment: Best Available Techniques (BAT)	A. Derden, VITO, Belgium
11.30 h	Manure treatment technologies which reduce nutrient leaching from pig production in Baltic sea region	H. Lyngsø Foged, CBMI, Denmark
12.00 h	Influence of anaerobic digestion of animal manures and energy crops on the fertilizer value of digestates	S. Sebastian Wulf, KTBL, Germany
12.30 h	Lunch & Posters	
	Field visits	
13.30 h	Transport to locations	
14.30 h	Visit locations, including discussion	
17.00 h	Return to hotels	
20.00 h	<i>Conference diner in Hof van Wageningen</i>	

Thursday 25 November

	Plenary session (Chair: O. Oenema, Alterra, Wageningen UR)	
9.00 h	Summary of day 1 and introduction of day 2	
9.15 h	Manure management and treatment in Poland	Z. Karaczun, SGGW, Poland
9.45 h	Small scale manure processing in France Brittany	J. Martinez, Cemagref, France
10.15 h	Manure treatment technologies: On-farm versus centralized strategies. NE Spain as case study	A. Bonmatí Blasi, GIRO, Spain
10.45 h	Break & Posters	
	Parallel workshop sessions	
		<i>Chair:</i>
11.15 h	I. Environmental performances of manure processing techniques	L. Samarelli and O. Oenema
	II. Economic feasibility of manure treatment	E. Mulleneers and O. Schoumans
	III. Treated manure as mineral fertilizer	H. Bos and G. Velthof
	IV. Strategies to increase nutrient use efficiency of manures	J. Casaer and J. Schröder
	V. Manure & co-digestion for energy recovery	K. Locher and K. Zwart
12.30 h	Lunch & Posters	
	Plenary session (Chair: M. Hamell, DG ENV)	
13.30 h	Sustainable use of phosphorus	J. Schröder, PRI-WUR, Netherlands
14.00 h	Managing phosphorus cycling in agriculture	O. Schoumans, Alterra-WUR, Netherlands
14.30 h	Strategies to increase nutrient use efficiency of manures	B. Chambers, ADAS United Kingdom
15.00 h	Biological nutrient removal and ammonia air stripping: full scale plants and experimental trials in Italy	S. Piccinini, CRPA, Italy
15.30 h	Break & Posters	
	Reports workshop sessions and discussions (Chair: M. Hamell, DG ENV)	
16.00 h	Reports of workshop sessions	
16.30 h	Conclusions, recommendations and general discussion	
17.00 h	Final remarks and closure	

Summary and conclusions

The workshop “Managing livestock manure for sustainable agriculture” was held in Wageningen, The Netherlands, on 24-25 November 2010. This workshop was organized by the European Commission DG Environment and the Ministry of Economic Affairs, Agriculture and Innovation of the Netherlands. The aim of the workshop was to promote exchange of information on manure management among Member States of the European Union, with special focus on manure processing. The workshop included plenary sessions with invited speakers from several Member States, poster sessions, workshop sessions, and visits to manure processing installations and farms with improved manure management. There were 160 participants from 25 countries, including policy makers, farmer organizations, environmental groups, and scientists (see the list of participants at the end of this report). Clearly, this shows the increasing interest in manure processing in the EU.

The presentations, workshop and excursions showed that many manure processing techniques are available (from low-tech separation to high-tech reverse osmosis techniques). Site-specific conditions and farm structure define the optimal combination of techniques, as well as the constraints found at regional level (e.g. the nitrogen surplus).

Economic analyses showed that large scale high-tech processing techniques are expensive and can only be affordable for high-income farmers or in regions with high livestock density, where all alternative solutions for manure management are even more expensive. In these instances, the cooperation of several farmers in the processing facility is necessary.

It is clear that, since the pressure on the environment by intensive livestock farming systems is high, the environmental legislation, both at European and national level, has put on them many obligations, such as strict (manure) nitrogen application standards and measures to reduce ammonia and greenhouse gas emissions. Manure processing techniques could be seen as the response to these legislative constraints as well as the consequence of increasing environmental protection awareness by all stakeholders. In addition, particularly for those regions with intensive use of livestock manure, the differences in nitrogen/phosphorus ratio of raw manure and the nitrogen/phosphorus ratio of crops may incite farmers to process manure in order to redistribute the nitrogen and phosphorus nutrients over different fractions.

It was stressed that manure processing is part of the solution to improve the use of nutrients in manure and to decrease emissions to the environment in regions with intensive livestock farming systems. In regions with extensive livestock systems, simple manure separation techniques may help to increase nutrient use efficiency and can be used for energy generation on the farm scale. Many other tools are available to improve manure management and would need to be better enforced at all scales (nationally/regionally, through better legislation; locally, through implementation on field). The results of the different oral and poster presentations indicate that there is still much room for improving nitrogen use efficiency in agriculture. Improvement of nitrogen use efficiency of livestock farming systems includes also the optimization of the feed composition. The whole chain from feed to manure application should be considered.

Various barriers to implement manure treatment have been indentified, such as high investment and operational costs for high-tech manure processing techniques, legislation (e.g. permits to built manure treatment installations, conditions for export/import of processed products), acceptance by society, and possible risks associated with their operation. These barriers limit implementation of manure processing in practice.

Manure processing techniques affect nitrogen emissions to water and air, the phosphorus inputs to soil, and greenhouse gas emissions, both during the process itself and through the use of the end and by products. An integrated system analysis is needed for an overall assessment of the environmental performances of these techniques, taking both nitrogen and phosphorus into account, as well as greenhouse gases emissions.

Further testing and optimization of currently available manure processing techniques are needed, taking into account the local situation. Moreover, innovation and further developments of new techniques (e.g. Alum, Annamox, and acidification) is desirable. In many countries, research is carried out on manure management and manure processing techniques. It is important to improve the pace of information exchange, so that results of the different projects can be used to optimize manure management and increase nutrient use efficiency in the EU.

The global rock phosphate resources are decreasing. This requires systems using less rock phosphate-based fertilizers and in which phosphorus in manure and other residues is fully reused as a fertilizer. Increased attention to phosphorus sustainability issues is needed. This is a big job of political awareness worldwide. The European Commission announced that it is working on a reflection paper on sustainable use of phosphorus within the context of resource efficiency and its intention to promote further awareness on phosphorus limited resources and best options to improve its use at sustainable levels.

Summarizing, the major conclusions of the manure workshop are:

- There is an increasing interest in manure treatment;
- System approaches (integrated system analysis) are needed for an overall assessment of performances of manure treatment techniques;
- Site-specific conditions and farm structure define the optimal combination of techniques;
- Many techniques are available, but further testing and optimization are needed;
- There are legal driving forces for manure processing, but other socio-economic driving forces may be needed. Further innovation and new techniques will be desirable;
- New generations techniques are for example Alum, Annamox, and acidification;
- Various barriers (legal, social, economic) have been indentified, which limit implementation in practice;
- There is still much room for improving nitrogen use efficiency in agriculture;
 - Differences between countries have been identified
 - Whole feed-chain analysis needed for improving
 - Pace of information exchange needs to be improved
- Nitrogen and phosphorus must be combined in system analysis;
- Increased attention to phosphorus sustainability issues is required; requiring greatly increased political awareness worldwide.

Summary parallel workshop sessions

I. Environmental performances of manure processing techniques

L. Samarelli and O. Oenema

The following processing techniques were discussed:

- anaerobic digestion
- manure separation in solid and liquid fractions
- composting of the solid fraction
- incineration of the solid fraction
- reverse osmosis
- aerobic – anaerobic treatment of the liquid fraction
- acidification

Anaerobic digestion

Relevant environmental trade offs

- Positive:
 - Best technique to reduce GHG
 - Production of energy for further treatments (not feasible otherwise)
 - Less odours
 - Improve recycling of nutrients (increased bioavailability)
- Negative:
 - Ammonia emission may increase
 - Management of digestate (nutrient content is the same)
 - Use of energy crops

Research needed

- Optimization of feed for improving the process
 - Genetic engineering of microbes
 - Using manure alone
- Effect on ammonia emissions
- Long term assessment of nitrates leaching and dynamics of C in soil after use of digestate
-

Manure separation

Relevant environmental trade offs

- Positive:
 - Less storage needed
 - Less transport
- Negative:
 - Energy consumption
 - GHG emissions
 - Management of the solid fraction
 - Polymers fate

Research needed

- Optimization of the process
 - Reduce energy
 - Improve separation efficiency
- Bio polymers allowing improved efficiency

Composting

Relevant environmental trade offs

- Positive:
 - Carbon in soil
- Negative:
 - Energy use
 - Ammonia emissions during the process
 - Management of end product
 - Metals in manure

Research needed

- How to reduce GHG and ammonia emissions
- How to improve microbial activity

Reverse osmosis (in combination with separation)

Relevant environmental trade offs

- Positive:
 - Higher nitrogen use efficiency
 - Reduction of mineral N fertilizer use
- Negative:
 - Energy consumption
 - Environmental risk related to discharge into surface water
 - Polymers fate
 - Salinization of soils
 - Losses of ammonia during spreading
 - Disposal of membranes

Research needed

- Optimization of the process
- More experience and trials
- Application techniques to avoid ammonia emissions
- Overall energy balance

Aerobic – anaerobic treatment

Relevant environmental trade offs

- Positive:
- Negative:
 - Energy consumption
 - GHG emissions
 - Nutrients are lost
 - Salinization of soils

Research needed

- Optimization to reduce energy consumption (e.g. Anamox)
- Effect on ammonia and N₂O emissions

Incineration

Relevant environmental trade offs

- Positive:
- Negative:
 - Resource efficiency (N and P)
 - Energy balance (in some cases)
 - Transportation and storage
 - Social acceptance
 - Emissions of NOx and other substances
 -

Research needed

- Effects on human health

Acidification

Relevant environmental trade offs

- Positive:
 - Less ammonia
 - Less methane
- Negative:
 - H₂S emissions
 - Production of acids
 - Prohibition of further treatments (biogas)
 - Risks of accidents

Conclusions

- Overall LCA for manure processing needed
- Manure processing as end of pipe solution
 - When there is a market for products
 - Depending on local conditions
- Manure processing at farm scale as part of integrated management to improve nutrient use
- Manure processing is part of the solution. What else is needed?
- Restructuring of livestock sector (changes in feed composition, animal numbers, concentration of production)?

Manure processing and integrated management are needed for a sustainable agriculture

II. Economic feasibility of manure treatment

E. Mulleneers and O. Schoumans

- The costs of manure processing have to be evaluated in the local context. There are clear differences between countries and related to the urgency to treat manure.
- The costs are dependent on the scale, e.g. low tech farm techniques versus high tech installations
- The economic feasibility are dependent of many factors. Changes in costs and benefits strongly influence the feasibility, such as changes in legislations/rules, taxes (e.g. sustainability tax on fertilizers), and P shortage.
- It is not a mission impossible!

III. Treated manure as mineral fertilizer

H. Bos and G. Velthof

Statement: *The demand for manure products with a similar nutrient efficiency as mineral (chemical) fertilizers will increase.*

There was a general agreement on this statement. It was stressed that the discussion about if a product is a mineral fertilizer is only important for nitrogen (because of the manure application standard in the Nitrates Directive). For P and K, there is no discussion if a product is a fertilizer.

Statement: *Manure products with a similar nitrogen efficiency as mineral nitrogen fertilizer should not be considered as manure in the Nitrates Directive.*

Some intensive farms have to export manure (because of the manure standards of the Nitrates Directive), but in the same time have to buy mineral N fertilizer to apply to their crops.

It is a mistake to change organic material in a chemical fertilizer. The Nitrates Directive should be changed. Add more products in the Nitrates Directive (slurry, treated slurry, concentrates etc.) with different application standards.

There is a difference between liquid fractions of manure and mineral N fertilizer; liquid manure products need specific application equipment.

Statement: *The composition of manure products with a similar nutrient efficiency as mineral fertilizers should meet certain quality standards.*

These standards have to be set and regulated at EU-level, e.g. as new fertilizer type in EU-regulation 2003/2003 for fertilizers or via the Nitrates Directive.

The EU regulation 2003/2003 for mineral fertilizers will probably also introduce regulations for organic fertilizer in 2011.

Quality standards are needed for trade of product.

Do not only focus on the composition of products. This may limit innovation. An other option is a quality standard for the treatment method/approach (instead of a standard for the composition).

Statement: *The nutrient efficiency of manure products has to be experimentally determined in field, pot and/or incubation studies with a reference mineral fertilizer.*

Nitrogen efficiency of manure products is included in the Nitrates Directive (because balanced N fertilization is included). N efficiency coefficients for new many products have to be included.

For inclusion of new fertilizers in the EU regulation 2003/2003, a technical file needs to be submitted. Besides information about composition, this document also should also include information about nutrient efficiency. There are guidelines about which research is needed to determine nutrient efficiency.

Statement. *Manure treatment resulting in products with a similar efficiency as mineral fertilizers is economic feasible in all regions where manure is produced.*

Disagreement about this statement. Use of raw slurry or digestate on own farm is most economic feasible method.

Statement. *The liquid fraction produced by simple slurry separation techniques cannot be considered as mineral fertilizer.*

The composition of the product is important, so no general conclusion is possible. However, there is still organic N in the liquid fraction, which makes these products less comparable with mineral N fertilizer. Separation can still be a solution for regions with a high P surplus but with room for N. However, the liquid and solid fractions remain manure.

Statement. *Low energy demanding treatment techniques, such as separated collection of urine and dung in livestock housing, will be the most profitable treatment option in the future. The collected urine can be used as mineral nitrogen fertilizer.*

The separation will take place in livestock housing (at source). There is a need for developments of housing systems (e.g. specific floor types). The economics are not yet clear. There several positive effects of separation at the source: separation of N and P, use of N as mineral N fertilizer, higher recovery of carbon and by that higher production of biogas, and higher potential for decreasing ammonia emission. Partly, it is going back to the old systems, where urine/liquid manure and solid manure were collected separately.

IV. Strategies to increase nutrient use efficiency of manures

J. Casaer and J. Schröder

Less than two decades ago, statements such as 'manure-N use efficiencies (NUE)* close to 80% should be our ambition for the near future', would surely have met massive opposition from at least some attendants of similar workshops. It is certainly encouraging that the reaction in the present workshop could be characterised by a 'yes, but....' response rather than by just a categorical 'no way!'. Now, what are these 'but's'?

In any system in which a considerable share of the manure-N input consists of N excreted during grazing (i.e. via urine and dung droppings), it will be quite impossible to reach a NUE of 80% due to the inevitably uneven and sometimes untimely application of N associated with these droppings. A second objection against too high NUEs applies to the heavier soil types on which late-summer and autumn applications provide the only pragmatic time windows. This is evidently not the best time to minimize N losses but the alternative, i.e. spring application, would not be conducive to a high NUE either due to soil compaction and/or losses due to run-off from water saturated soils. Solid manures with their inherently lower share of ammoniacal N will rarely show a NUE as high as 80% neither, at least not in the first season following their application. In the very long run after many repeated applications, however, the NUE of these type of manures will increase stronger than that of slurry-like manures. It was also emphasized that NUEs of 80% require very specific application techniques that can almost fully avoid volatilization of ammonia. Effective injection techniques, however, are simply impossible on stony soils or very heavy clay soils. Apart from these technical considerations, some of the participants underlined that legally imposed, too high NUEs, could make arable farmers reluctant to accept excess manure from livestock farmers, whereas such a better regional distribution of manure could and should be part of the solution.

One could reason that legally imposed high NUEs make farmers decide on a voluntary basis to refrain from untimely applications. Under those circumstances regulations on spreading bans and/or storage capacity would become redundant. However, participants responded to this by saying that this will only work if there is a tight upper limit to the permitted total amount of N and/or the price of mineral fertilizer N is sufficiently high. Without that, the return on investments in storage capacity or low-emission equipment will generally be too low. So, additional regulations, preferably supported by investment grants seem necessary and are indeed implemented in almost all member states, the UK being apparently one of the few exceptions.

In addition to appropriate storage capacity and suitable equipment for a more precise application of manure, manure treatment may also contribute to higher NUEs. It was suggested, however, that the word 'manure treatment' is presently being used in a too loose manner, as some 'treatments' do not at all contribute to a better utilization of resources. Removal of N (e.g. via denitrification) or P (e.g. via flocculation with Fe), for instance, is certainly a treatment in a broad sense, but it has little to do with the re-use of resources. To a certain extent this criticism may apply to anaerobic digestion (AD) too. AD can certainly be economically or technically supportive to treatments *sensu strictu* (such as separation), but AD may aggravate local NP surpluses as soon as operators decide to import co-products to increase the biogas production.

The attendants agreed that there is a great need for a balanced, integrated approach. Or in other words: what is good for the utilization of N, is not necessarily good for the achievement of other objectives, as measures directed at a better use of N may carry a price in terms of animal welfare (e.g. grazing, use of bedding material), GHG-emissions, energy requirements (e.g. reversed osmosis), conservation of soil structure (e.g. by avoiding spring applications). In conclusion, higher NUEs than the ones currently adopted are technically feasible in many member states but not under all circumstances, because of:

- specific pedo-climatic conditions and their consequences for the available management options,
- the very nature of some manures or specific fractions from them,
- undesired interference with other societal goals.

*manure-N use efficiency (value)= fertilizer N equivalency = N fertilizer replacement value = N use coefficient = potential saving of mineral fertilizer N = manure-N recovery / mineral fertilizer recovery)

V. Manure & co-digestion for energy recovery

K. Locher and K. Zwart

- Multiple use of biomass is an option but not a necessity. Waste is better than energy crops.
- Import of substrates is not sustainable, but the market is deciding. Methane capture is the baseline. The farmer/entrepreneur should be stimulated to develop BAT.
- Digesters (farm or industrial) should be built on sites where electricity, heat and digestate are fully exploited. Export of green gas is an option for farm scale digesters, better control on process and digestate is a pro for industrial digesters.
- The choice for monodigestion or codigestion depends of the context (sustainability of the agricultural sector, need for reduction of manure surplus, GHG and energy). The farmer/entrepreneur should be stimulated to develop BAT.

Abstracts of oral presentations

Manure Treatment: Best Available Techniques (BAT)

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The Centre for Best Available Techniques (BAT) is founded by the Flemish Government, and is hosted by VITO (the Flemish Institute for Technological Research). The BAT centre collects, evaluates and distributes information on environmental friendly techniques. Moreover, it advises the Flemish authorities on how to translate this information into its environmental policy. Central in this translation is the concept of "BAT" (Best Available Techniques). BAT corresponds to the techniques with the best environmental performance that can be introduced at a reasonable cost.

At present, the BAT Centre published more than 45 Flemish BAT studies for several (industrial) sectors. Besides this activity, the BAT Centre is also involved in the Seville Process as a Member of different Technical Working Groups and of the Information Exchange Forum.

This presentation will focus on the conclusions of the Flemish BAT study for manure processing.

Besides manure land spreading, the BAT study for manure processing describes four representative pig manure treatment scenarios, which are a combination of two or more techniques:

1. Separation of the liquid and solid fractions of manure, followed by biological treatment of the liquid fraction.
2. Drying of the manure with heat from the ventilation air of the stables.
3. Separation of the liquid and solid fractions of manure, followed by biological treatment of the liquid fraction and evaporation of the effluent.
4. Anaerobic co-digestion.

The BAT study concludes that none of the above mentioned treatment scenarios are BAT on sector level for pig manure processing, due to the excessive costs of the techniques. However in specific circumstances where farmers can cope with the costs the treatment scenarios 1, 2 and 3 are BAT. Besides these techniques, mobile installations for manure treatment can be BAT for small farms as well.

For poultry manure land spreading was compared to export of raw poultry manure, composting followed by export and incineration. These processing techniques are economically viable for the sector and are selected as BAT at sector level in the BAT study.

At this moment, an additional Flemish BAT study is in progress. Subject of this study is the co-digestion of manure and/or energy crops and/or organic biological waste. This study will focus on techniques to treat digestate and biogas. The study will be completed by the end of 2011.

An Derden,
11/11/2010

Manure treatment technologies which reduce nutrient leaching from pig production in Baltic sea region

By Henning Lyngsø Foged, Project Manager, Agro Business Park, eMail hlf@agropark.dk, Tel. +45 8999 2536, Mob +45 4034 8625

Governments of the EU Member States shows in policies, legislation and financing programmes a considerable interest for manure processing technologies, not at least biogas production. As examples, the Danish Government foresees in their "Green Growth" action plan from 2009 that up to 50% of all livestock manure shall be treated for energy purposes by 2020, and the Polish Minister of Agriculture, Marek Sawicki has recently stated, that the Polish Government currently plans to exploit an estimated Polish annual biogas potential of 2 billion m³ per year by 2020, which actually is equal to around 5,500 large farm scale biogas plants. Many scientists and bioenergy companies in the EU, here under in Holland, explores the possibilities for conversion of livestock manure to mineral fertilisers, clean water and some other useful rest fractions, using for instance a variety of livestock manure separation technologies and chemical processes. In the same time, efforts are made in Spain, Belgium, UK and other countries, for converting the nitrogen in the livestock manure to nitrogen gas (N₂) by use of technologies like nitrification-denitrification and combustion.

The considerable focus on livestock manure processing technologies for the last few years, has its background in the increasing awareness of the potential for resolving not only environmental challenges, but also the possibility to in this way reach policy goals related to waste handling, greenhouse gases/climate, and the production of renewable energy.

Officially, concerns for the environmental impacts of farming with respect to plant nutrients started with the Nitrates Directive in 1991 (91/676/EEC), introducing for instance provisions on storage and spreading of livestock manure. The IPPC Directive (96/61/EEC – now 2008/1/EEC) came 5 years later, and introduced requirements for the environmental permitting of intensive pigs and poultry farms. It also serves as basis for the BREF document (Reference Document on Best Available Techniques for Intensive Rearing of Pigs and Poultry), which functions as a reference for national descriptions of BAT's (Best Available Technologies) that can be demanded to be installed and used by intensive pig and poultry farms in order to prevent emissions of nutrients to air, soil and water. Use of specific technologies can in a wider sense be regulated under the Water Framework Directive (2000/60/EEC).

A study initiated by the private foundation Baltic Sea 2020, has suggested, that some manure processing technologies on intensive pig farms has a positive environmental effect and helps to better re-circulate nitrogen and phosphorus in the agricultural turnover, while other technologies have direct or indirect negative effects. Anaerobic digestion, separation technologies and more effective P management measures were identified as having the best potential to reduce leaching of nutrients to water. The study also revealed that only 5 out of 8 EU Member States around the Baltic Sea actually has official manure standards.

The attention to manure processing technologies in the mentioned EU legislation is presently most focused on livestock manure storage and spreading, and on the airborne emission and nuisances from stables and stores. There is a possibility to include technologies which reduce leaching of nutrients to water in the ongoing revision of the BREF, which should be finalised next year.

The environmental impact of livestock manure treatment technologies, positive or negative, justifies a better validation of these impacts, and the regulated use of those technologies.

Influence of anaerobic digestion of animal manures and energy crops on the fertilizer value of digestates

Sebastian Wulf, Hannes Döhler and Helmut Döhler

KTBL, Germany

Physical and chemical properties

Anaerobic digestion is characterised by a breakdown of organic matter and a release of carbon with the generation methane and carbon dioxide. This results in a substantial reduction of COD and BOD and a smaller C/N ratio. The commonly claimed benefits of anaerobic digestion on manure properties are a reduced odour emission, a reduction of human, animal and phytogetic pathogens and a better flow property, which leads to a reduced energy requirement during mixing of manures and a more rapid infiltration into the soil after application.

Since only a small proportion of the total manure mass is decomposed in a sealed anaerobic digester, the total content of nutrients in the digested manure does not differ a lot from raw slurries. However, data already from the 80th show a reduction in slurry DM content as a result of anaerobic digestion with a difference of around 25% between raw and digested slurries. The organic forms of nitrogen and phosphorus are converted into water soluble and readily available Ammonium-N and P. Digested manures show a 10-15 % higher proportion of Ammonium-N. During anaerobic digestion the pH increases by 0,5 to 1 unit. The N- and NH₄-content in digestates from energy crops (as well as from cofermentation of energy crops and slurries) differ slightly more from undigested manures

Ammonia losses

Under unfavourable conditions around 40 -50 % and up to 100 % of ammonium -N of slurries can be lost by ammonia volatilization, particularly when inappropriate techniques are used at inconvenient time. Due to the increased pH-value of digested slurry the initial losses are higher compared to raw slurries. On the other hand, the better flow properties allow the digestates to infiltrate more rapidly into the soil. These effects seem to level each other out and losses appear to be similar within a range of 20 to 50 % after surface application. The losses of energy crop digestates seem to be somewhat higher, when dry matter contents are above 7 or 8 %. Therefore the same measures for the reduction of emissions should be taken as for animal manures.

Fertilizer value

Organic N of digestates contributes only to a small extent to the N-nutrition in the year of application. Based on the ammonium-N content, the fertilizer value of digested slurries seems to reach the same value as raw slurries and mineral fertilizers, provided that ammonia emissions are reduced. A smaller biological N immobilisation may lead to a slightly better crop response, which reflects the smaller C/N ratio of digested slurries. However, there is no evidence of an improved utilization of total slurry N due to an increased NH₄-N content. The limited data on agronomic assessments have generated inconsistent results. Most of them show no significant differences between MFE (Mineral Fertilizer Equivalent) of slurries, digested slurries and digestates from slurries and energy crops. The MFE value of topdressed digestate makes around 50-60 % in winter crops. In maize even MFE-values of up to 90 % are reported, most probably due to high mineralization of soil organic N during spring time.

Manure management in Poland

Zbigniew M. Karaczun

**Department of Environment Protection
Warsaw University of Life Sciences**

Currently the number livestock units per 100 ha of farmland in Poland is approximately 50. At present approximately 50 million tonnes of farmyard manure and approximately 125 million m³ of liquid manure are produced in Poland each year. Taking into account the content of N in livestock manures in Poland, this amount still leaves a large safety margin as compared with 170 kg N per year⁻¹. The nitrogen surplus in Poland is therefore lower than in most EU countries and was calculated in 2009 on the 50,9 kg N ha⁻¹ of farmland.

Nevertheless there are a big difference between regions. The high nitrogen surplus is found in the northern regions of Poland, particularly in the Wielkopolskie, Kujawsko-Pomorskie and Łódzkie provinces (more than 70 kg N ha⁻¹ of farmland), the lowest, less than 22 kg N ha⁻¹ of farmland, is found in the Dolnośląskie and Podkarpackie provinces.

The most important measure to improve the manure management are provisions on the Act on fertilisers and fertilisation (Dz.U. 147/2007 item 1033). The Act was first adopted in 2000 and its aim was to prepare Polish farmers to implementation of the EU requirements. It contributed to promotion of proper storage and application of fertilisers. It was substantially changed in 2007.

Another important measure was designation of areas particularly vulnerable to pollution caused by nitrates from agricultural sources in which the discharge of nitrogen from agricultural sources into sensitive waters should be reduced (PVAs), as a part of Nitrate Directive implementation. Currently in Poland are 19 PVAs which cover approximately 1,49% of the country area.

On 13th July 2010 Council of Ministers accepted the document entitled: Directions of development for agricultural biogas plants in Poland between 2010 – 2020. The goal is creation the optimal conditions for the developing the agricultural biogas installation to ensure that by the year 2020 this type of installations will be build in each Polish commune. . The expected results of the programme are e.g.¹:

- improvement of nation's energy security,
- use of organic wasted which emit greenhouse gasses for energy production,
- obtaining the significant quantities of organic fertilizers in the form of post-fermentation reminders from an agricultural substrate in the form of a granulated product;
- increase in own income for local society and governments.

It is to early to assess the programme implementation, but earlier experience shown that without the administration support it will not be possible to obtain the expected results.

¹ Ministry of Economy, 2010: Directions of development for agricultural biogas plants in Poland between 2010 – 2020. MG. Warsaw.

Small scale manure processing in France Brittany

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Abstract

Farms and farming regions across Europe tend to be highly individual; consequently, the best systems to handle the manures produced will tend to be specific to each area, reflecting the local situation. Likewise, no single manure management system can be put forward as a universal solution as the farm requirements (reflecting the local environmental impacts) varies across Europe. The manure management system is considered seriously today for two reasons: the need for efficiency of operation to increase profitability and the need for environmental responsibility.

In France, Brittany northwest of the country is identified as one of the main centres of animal production in the EU. During the past decade, production became more and more specialized but remained generally a family operation. Most of the production is organized in producer's co-operatives groups which included a breeding scheme, technical assistance for production, trade and shipment and payment according to carcass quality. There are about 30 000 agricultural farms in the Brittany region, representing a value of 7 billions euros, among 70% originating from animal production, so this agro-food sector is a main employer in the region.

Several alternatives for manure management and treatment are available. One such method is aeration, particularly developed in Brittany is the intermittent aeration processes (IAP). Information is needed on the actual performances of such systems with regard to nutrient (N, P) removal efficiencies, the fate of nitrogen forms, and separation performances, but also as regards greenhouse gas emissions balance and hygienic abatement aspects. From 2000 to 2010, the Cemagref Institute has conducted a series of field studies to collate such data. The objective of this overview is therefore to provide some recent data on such small scale liquid manure treatment systems.

Intensive biological processes for eliminating nitrogen and removing odour are being installed by private companies. At the beginning of 2008, there were about 400 treatment plants built and treating about 3 million m³ of slurry.

Aeration of the slurry induces nitrification and subsequent denitrification into the atmosphere as di-nitrogen gas (N₂). Remaining slurry is allowed to settle naturally and separates into an odourless liquid and sludge. The treated liquid, which is around 65% of the manure volume, contains only 2-7% of the original nitrogen, and only 10% of the phosphorus, and therefore can be recycled rapidly for irrigation with a reduced environmental risk. Nitrogen removal in gaseous forms varied between 60-70% of the total N of the raw slurry: between 8 and 10% of the total nitrogen of the raw slurry was contained in the solid phase (from mechanical separation), while 2-7% and 20-29% were located in the liquid effluent and sludge respectively (Béline *et al.*, 2004²; Martinez & Béline, 2008³).

² Béline, F., Daumer, M.L., Guiziou, F. 2004. Biological aerobic treatment of pig slurry in France : nutrients removal efficiency and separation performances. Transactions of the ASAE, 47 (3), 857-864.

³ Martinez, J., Béline, F. 2008. Nitrogen removal during aerobic treatment of liquid pig manure in Brittany, France. Pig News and Information, 29 (3), 1-6.

For phosphorus, between 25 and 30% of phosphorus was found in the solid phase while 10-25% and 63-73% were located in the liquid effluent and the sludge respectively. The majority of copper and zinc (90%) accumulated in the sludge or into the solid phase.

With the second step of the study based on a comparative assessment (field measurements) between intermittent aeration and conventional farms (with storage follows by land-spreading), we found a large decrease of the greenhouse gases (methane and nitrous oxide) and ammonia when a biological treatment is compared to simple storage.

The reduction was 30-52% for NH_3 when the biological plant included mechanical separation and was 68% when there was no separation. Greenhouse gases (CH_4 and N_2O) were reduced by about 55% whatever the type of biological treatment plant (Loyon et al., 2007⁴).

The behaviour of enteric bacteria was studied in the effluents of biological IAP. Microbial analyses were performed on raw pig slurry and treated (aerated) pig effluent (corresponding to sludge in settling tank). Indicator counts in raw pig slurry varied between 2.0×10^2 to 1.4×10^5 CFU for *E. coli* and from 1.8×10^3 to 3.1×10^5 CFU / g for enterococci. The aerobic treatment affected the survival of enteric bacteria as the average \log_{10} reduction between raw slurry and sludge were 1.9 \log_{10} for *E. coli* and 1.3 \log_{10} for the enterococci. However, the pathogenic bacteria *Salmonella* and *Listeria monocytogenes* which were isolated in 59% and in 29% of raw slurry respectively, were also detected in 20% of the treated slurry. So the biological manure treatments, originally developed to remove nitrogen and phosphorus, make it possible to decrease the level of enteric bacteria, but do not achieve complete sanitization of the by-products which are intended for spreading on agricultural land (Pourcher et al. 2008⁵).

Finally the cost of the biological aerobic treatment of pig slurry is important and varied from 8 to 20 Euros/ m^3 of treated slurry. The running cost is mainly due to the energy requirement for mechanical separation and for oxygen supply to the reactor.

Face to the increase of the energy cost, anaerobic digestion could play an important role in the management of organic wastes in general but including livestock manures. There are as well a number of "biogas" plants installed in Brittany. The presentation will overlook some on-going projects.

⁴ Loyon, L., Guiziou, F., Béline, F., Peu, P. 2007. Gaseous emissions (NH_3 , CH_4 and CO_2) from the aerobic treatment of piggery slurry-Comparison with a conventional storage system. *Biosystems Engineering*, 97, 472-480.

⁵ Pourcher, A. M., Fravallo, P., Dabert, P. 2008. Impact of biological treatment of manure on micro-organisms of sanitary interest: example of 17 piggeries in Brittany. 40^{èmes} Journées de la Recherche Porcine, 40, 19-24.

Manure treatment technologies: On farm versus centralized strategies. NE. Spain case study

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Organic wastes which composition allow their valorisation as fertilizers or organic amendments must be considered as resources to be managed adequately, instead of pollutants to be removed. The optimal use of manure as a fertilizer depends on local conditionals: availability of accessible soils and crops to be fertilized, nutritional requirements and productivity of these crops, presence of other competitive organic fertilizers in the area, climate factors, density and intensity of farming, property structure of farms and agricultural lands, distances and transport costs, energy prices,...

Manure processing should be considered in the framework of a Nutrient Management Plan (NMP) designed under local conditions and considering cultivable soils as the end-users of this resource. A NMP can be defined as a set of actions conducted in order to adequate manure production to the demand as quality products. This set of actions must include: minimization of flow rates and their content on limiting components (e.g. water, nutrients and heavy metals); fertilization plan; economical costs analysis and, finally, analysis of feasible treatments to be applied in order to improve the management capability.

These treatments can vary from simple (adequate storage, mixing system and spreading method) to complex (i.e. considering a biogas plant and a nutrient recovery treatment) (Bonmatí A., Flotats X. (2003^{a,b}) but always tending to increase the management capability and the product value, and to decrease the global management cost. When, in a given geographical area, the offer of nutrients is higher than the demand the complexity of the system requires a higher level of management, and then a collective management could be favourable. This difference, individual or collective management planning, is thought to be the key factor for implementing individual -farm scale- or collective -large scale- facilities. In this sense, scale and technological complexity must be the result of a management planning and not an objective by itself.

Catalonia, NE of Spain, has a high livestock farm concentration with more than six million pigs, 0.65 million cows and 38 million poultry (DAR, 2008). The high density of livestock in some areas linked to the insufficient accessible arable land, drive to a number of environment side effects. Nowadays in Catalonia there are operating 42 collective Nutrient Management Plans, joining 2594 farms and managing 21,879,631 kg N/year (DAR, 2008). More than 100 farms have installed some kind of manure treatment system, and exists more than 6 centralized treatment plants. Main factors explaining successful experiences in Catalonia are the involvement of farmers, contractors, technology suppliers and authorities, prices of energy and mineral fertilizers and the existence of a NMP as a global framework for actuations, either at individual or collective level (Flotats *et al.* 2009).

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Sustainable Use of Phosphorus

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About three quarters of the phosphorus (P) in mined rock phosphate is processed into tradable products, mainly fertilizer P. Of this fertilizer P only one fifth ends up in our food. The complement, that is approximately 85%, is stored in waste heaps near mines, accumulated in agricultural soils, disposed of in landfills and constructions, or emitted to surface water to the detriment of the environment. Whenever a resource is nearing depletion, people typically call for a more efficient use. There is nothing wrong with this pursuit but, by definition, efficient use is not sufficient for a finite resource. An improved use efficiency could yet postpone the full depletion of fossil reserves (<150 years left with a business-as-usual policy) and at least buy the time needed to work on a truly sustainable solution, that is a complete recycling of P from societies back to agriculture. Policy makers should already now start thinking of systems using less if any rock phosphate-based fertilizer P and systems in which food production, processing and consumption are ultimately integrated in such a way that P in excrements and other residues can be easily and fully reused as a fertilizer.

The present paper will give an estimate of the gross future demands of P in view of human population growth, dietary changes and the aspired production of energy via crops. This estimate will use the present ratio of fertilizer use and crop production as a point of departure. Subsequently, the paper will present examples of how the fertilizer use efficiency in agriculture can be improved via e.g. a better integration of feed production and livestock production, erosion control, better fertilizer recommendation systems including application methods, and waste treatment. In addition to this the paper will address some of the aspects needed to turn industrial and urban wastes into an appreciated alternative for mineral fertilizer P. The potential for the latter is, among other factors, determined by the presence and the type of waste collection system, by prevented contamination with constituents making wastes unsuitable as fertilizer, and by transport distances. The above is of extraordinary relevance to the European Union (EU), as food production in the EU relies on an annual import of around 1.5 Mt P ('3 kg P per inhabitant').

Keywords: fertilizer, land use, manure, phosphate rock, phosphorus, recycling, use efficiency

Reference

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Managing phosphorus cycling in agriculture; a review of options for the Netherlands

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Abstract

In the Netherlands, intensive livestock farms face increasing economic costs for manure disposal, because of the limited land area and decreasing application limits over time. Forecasts suggest that the unbalance between the total supply of manure nutrients and the total 'room' for manure nutrients will further increase during the next years and may amount up to 60 million kg of phosphate by 2015, depending also on the export of manure to neighbouring countries. So far, manure treatment has not contributed much to relieve the pressure on the 'manure market', because of various technical and socio- economical reasons. At the request of the Ministry of Agriculture, Nature and Food Quality, Wageningen UR has explored possible options that contribute to a drastical decrease of the pressure on the manure market. This presentation summarizes the results of the explorative studies.

Three possible options for relieving the pressure on the manure market were explored. The first option explored the possibilities to decrease the total import of phosphate through decreasing the use of inorganic phosphate fertilizer and decreasing the phosphate content of animal feed (also through bio-refinery of feed stock ingredients). The second option explored the possibilities for further optimizing the use of manure phosphate on agricultural land of the Netherlands. The third option explored the possibilities to increase the export of phosphate containing products, through recovery of phosphate from manure and wastes.

A further decrease of the phosphorus content in animal feed by on average 20% is the most cost-effective option. This can be done by selecting feed ingredients with a relative low phosphorus content and a high ratio of digestible phosphorus – total phosphorus. It may contribute to a lowering of the manure burden by about 9 million kg of phosphate. Through biorefinery of feed ingredients, the ratio of easily digestible phosphorus to total phosphorus in feed can be further increased. It is expected that biorefinery may contribute to a further lowering of the total phosphate input into agriculture by 1 - 5 million kg per year. The second option explored how manure separation may increase the 'room' for manure application on agricultural land in the Netherlands. The liquid fraction of separated manure is relatively rich in nitrogen, while the solid fraction is relatively rich in phosphate. The result suggests that manure separation on livestock farms may contribute to increase the application of manure phosphate on agricultural land by 1 - 5 million kg phosphate per year. The third option explored the recovery of phosphate from animal manure as phosphate fertilizer, biochar and elementary phosphorus, and to export these phosphorus-rich compounds to other countries. These routes require an integrated approach of manure separation and processing techniques, with active participation and commitment of many stakeholders, because the recovery of phosphate from animal manure requires significant financial investments and institutional arrangements. However, these routes have the potential to remove some 40-60 million kg phosphate from agriculture and thereby contribute to achieving a 'zero-balance' at the national phosphate input-output balance, also for the longer term.

Strategies to increase nutrient use efficiency of manures

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Abstract

Livestock manures are a valuable source of crop available nutrients and organic matter that can improve soil fertility and quality. The efficient recycling of manure nutrients to agricultural land can reduce the need for manufactured fertiliser use, in particular nitrogen-N (which is energy intensive to produce) and phosphate (which is a finite natural resource). However, the nutrient value of livestock manure additions is *not* always fully appreciated and exploited.

To make effective use of manure nutrients and in particular nitrogen, it is important to consider the whole manure management system *i.e.* housing, storage and land spreading. The nitrogen content of livestock manures is present in two main forms:

- *Readily available nitrogen*-RAN (ammonium, nitrate and uric-acid N), which is potentially available for rapid crop uptake.
- *Organic nitrogen*, which becomes more slowly available for crop uptake over a period of months to years.

Livestock slurries and poultry manures are typically higher in RAN than farmyard (deep litter) manures.

To maximise the N efficiency of livestock manures it is important to minimise losses from the RAN pool during housing and storage (mainly from ammonia emissions), and following land spreading (mainly from ammonia emissions and nitrate leaching).

There are a number of manure management practices that can be used to minimise ammonia losses following land spreading, including rapid soil incorporation on tillage land and the use of slurry band spreading (trailing hose/shoe) and shallow injection techniques. To reduce nitrate leaching losses it is important to apply manures in spring/summer when there is a crop demand for N, rather than in the autumn/winter when there is little crop demand and nitrate in the soil is likely to be leached into ground/surface waters; hence, the introduction of 'closed spreading periods' in Nitrate Vulnerable Zones. The provision of adequate slurry (manure) storage capacity is necessary to achieve this aim.

In the case of liquid manures, covering slurry stores, solid:liquid separation, anaerobic digestion, acidification technologies etc. all have a role to play in stimulating improved nutrient use efficiency. Similarly for solid manures, keeping them 'dry' during housing/storage, bedding and additive use, store covering etc. are management practices that can be used to improve nutrient use efficiency.

Making effective use of manure nutrients is important for farmers to improve the economics of crop production and to protect the environment, and for society as part of climate change mitigation (i.e. less manufactured fertiliser N use) and the sustainable use of finite natural resources (i.e. phosphate fertiliser supplies).

Biological nutrient removal and ammonia air stripping: full scale plants and experimental trials in Italy

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Biological nutrient removal: full scale plants

Two farm Sequencing Batch Reactor (SBR) plants for treating piggery slurry were monitored for a period of twelve months. The slurry is collected into a mixing and pumping tank from where it is pumped into a centrifuge. The liquid fraction is sent to the equalisation tank, where it is mixed with other supernatant deriving from the sludge settling and dewatering. Submerged pumps load alternately the two Sequencing Batch Reactors at the beginning of each de-nitrification phase, during which only the mixer is operating. Each SBR is equipped also with two submerged aerators. The clarified effluent is discharged, by means of a submerged pump installed about 1 m below the minimum liquid level, into some storage lagoons and/or in the public sewer. Excess sludge is withdrawn before the end of each oxidation phase and is transferred to a gravity settler. The supernatant returns to the equalisation tank, while the settled sludge is transferred to a gravity thickener. The thickened sludge is dosed to a centrifuge after addition of cationic polyelectrolite; the thickener supernatant and the liquid fraction from the centrifuge return to the equalisation tank.

The SBR has been demonstrated to be an extremely efficient biological process, capable to obtain very low nitrogen and phosphorus concentrations from highly concentrated wastewaters - like piggery slurry - with COD, nitrogen and phosphorus removals higher than 95%.

This process can represent a new chance for solving environmental problems generated by large industrial piggeries, when other more "sustainable" options cannot be adopted in the short term. Electric energy costs, that represent the main cost item, can be highly reduced if the primary and secondary sludge were anaerobically digested to produce biogas for Combined Heat and Power unit (CHP).

Ammonia air stripping: experimental trials

The experimental activities were carried out within a project of the Emilia-Romagna Region and the goal was to establish the feasibility of the removal of nitrogen from pig and cattle slurry by stripping using simplified plant and without changing the slurry pH.

The results obtained from the experimentation showed the stripping process to be feasible by air insufflation and heating, without the need to chemically raise the pH value, whether for swine slurry or cattle slurry, provided that this last is previously treated by anaerobic digestion.

A considerable increase was seen in ammonia nitrogen removal efficiency, with same treatment time or temperature, when slurry processed by anaerobic digestion was loaded into the pilot reactor rather than fresh slurry undigested.

Much higher is the concentration of ammonia nitrogen (65% of TKN in digestate compared to 51.5% of TKN in fresh slurry), higher is the efficiency for removing ammonia nitrogen. Furthermore, much lesser is the level of dry matter on the mass loaded into the reactor (3.05% in digestate against 5.2% for fresh slurry), greater is the airflow capacity insufflated into the reactor to remove ammonia nitrogen solute into the liquid fraction and to bring it into an ammonia gaseous state in the headspace. Much higher is the initial pH of loaded slurry in stripping reactor, much greater is easiness of ammonia stripping: as a rule, pH of digested is higher than pH of fresh slurry even by one point (pH 7,95 digested cattle slurry vs pH 7,2 fresh cattle slurry).

Ammonia nitrogen removal efficiency increases significantly if the slurry is subjected to a high insufflation/bubbling rate as also when the process temperature is equal or above 60°C.

Stripping technique introduced in a chain with slurry anaerobic digestion and combustion of biogas produced through Combined Heat and Power unit , gives two benefits: energy recovery (specially thermal energy) for energy demands of the process and the presence of digestate, which increases stripping efficiency compared to the raw slurry. Therefore, the ammonia air stripping technique at high temperature (60-70°C) represents an interesting possibility for reducing nitrogen content in slurry, as long as the energy consumption required by the technique can be supported by a low-cost energy source, such as biogas from anaerobic digestion.

Abstracts of posters

Manure processing in Flanders: an overview

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Several regions in Flanders are characterized by intensive livestock rearing and a local manure surplus. The Flemish Manure Decree prescribes several measures to cope with this surplus, such as the obligation for farmers to process a certain percentage of their net manure surplus.

Various manure processing techniques have been developed for processing different types of manure in Flanders. These techniques aim either at converting the manure into an organic fertilizer, which can be exported or disposed on non-farming land, or either at neutralizing the nutrients contained in the manure (e.g. biological conversion of N into N₂-gas).

Based on results from the previous VCM inquiry, 112 manure processing plants were operational in 2009 and approximately 21.5 million kg N (2.1 million tons of manure) has been processed in the period July 2008-June 2009. The most widely used technique in Flanders is biological conversion into N₂-gas (50% of the installations), mainly used for treating pig manure. The largest amount of manure (in terms of kg N) is being processed by means of biothermal drying, followed by biological conversion (29% and 24% of the total amount processed, respectively).

At the workshop, results from the most recent VCM inquiry (considering the period July 2009-June 2010) will be presented.

Ammonia volatilization potential of swine manure treated by In-Storage Psychrophilic Anaerobic Digestion

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Achieved by closing manure storage facilities with an air tight geomembrane cover, In-Storage Psychrophilic Anaerobic Digestion (ISPAD) was designed to offer livestock facilities a feasible anaerobic digestion technology. This psychrophilic system is operated in batch mode under ambient climatic conditions. The ISPAD anaerobic microbial populations were found to acclimate to low temperatures and show a robust psychrophilic and mesophilic character for carbohydrate activity while remaining mesophilic for protein degradation. Besides losing a negligible amount of ammonia in the biogas, ISPAD thus offers a slow rate of protein degradation resulting in manure richer in mineralized nitrogen (ammonia and ammonium or TAN), as compared to that from mesophilic digestion or stored under air exposure. Nevertheless, additional nitrogen conserved by ISPAD can be lost by ammonia volatilization during land spreading. The objective of this project was therefore to compare land spreading nitrogen losses for swine manure treated by IPSAD and obtained from an open tank. The tests were conducted using four different top soils (a sandy loam, a loam, a silty loam and a clay soil) and a fine sand, and land application was simulated using wind tunnels. The ISPAD manure was indeed found to have a higher ratio of TAN/TKN as compared to that stored in an open tank. The amount of ammonia nitrogen volatilized during the wind tunnel tests varied with both manure and soil type. Within each manure type, the amount of ammonia volatilized was highest for clean sand and lowest for the clay soil. Soil cation exchange capacity (CEC) and water holding capacity were the two parameters having a significant influence on ammonia volatilization. For the three loams, the ISPAD manure lost less ammonia nitrogen with 80 % of its TAN remaining after 47 hours as compared to 65 % for the open tank manure. As a result and once spread on land, the ISPAD system can produce swine manure with a TAN 21 % higher than that of conventionally stored manure for an equivalent phosphorus value.

Keywords: in-storage-psychrophilic-anaerobic-digestion, swine manure, nitrogen fertilizer value.

Closing nutrient cycles

Sandra Boekhold, Soil Protection Technical Committee (TCB)

The TCB has prepared an advisory report to the Dutch ministers of environment and agriculture on closure of nutrient cycles. The TCB is concerned about the impact of the ongoing application of excess manure on soil, groundwater and surface water quality.

A growing demand for food in a world with an increasing population and growing prosperity emphasizes the need for increased nutrient use efficiency, reduction of losses and waste and closure of nutrient cycles. In a development towards a biobased economy, our dependency on healthy soils increases even more. Closure of nutrient cycles is a prerequisite for sustainable soil use.

The import of nutrients should be balanced with the amount of agricultural land available for efficient nutrient use in agriculture. In the current practice in the Netherlands, this balance can only be achieved by reduction of the amount of animal manure by reducing livestock.

Re-expansion of livestock may be expedient only when manure has become a common international trading commodity. This may be realized when manure processing develops towards a production system of economically attractive fertilizers with a stable and known composition. However, this is strongly dependent on the success of future innovations in manure processing technology.

Ammonia stripping process efficiency: influences of pig slurry characteristics

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Key words: air stripping; nitrogen; ammonia; livestock waste; nutrients recovery

Intensification and specialization of agriculture and livestock production have led to the sharpening of the environmental impacts of growing food production. Thus, reduction and mitigation of these impacts along with the recovery of valuable nutrients, such as nitrogen, have become issues of primary concern. In this work, the influences of pig slurries characteristics were studied with regard to ammonia stripping efficiency. Raw (RS), anaerobically digested (DS) and partially digested slurries (PDS) were used and the effects of storage periods, along with pH and VFA concentrations, were evaluated. Experiments were run in a lab-column reactor (100 cm height and 6 cm internal diameter) with slurry recirculation and under constant temperatures and flow rates, 40°C/20 l min⁻¹ and 50°C/45 ml min⁻¹, for air and slurry respectively.

Preliminary results show high ammonia removal efficiencies for all the considered slurries. PDS presented the poorest performance, with efficiencies up to 60%, while DS and RS resulted in comparable efficiencies, between 70% and 90%. In the case of DS, 6 months storage improved stripping efficiency by almost 30%. pH values kept stable or slightly increased during column operation with the exception of RS, where values below 8 were reached. No significant differences in process efficiency were observed for all the studied slurries when the initial VFA concentrations were modified up to 10 g/l (by synthetic acetate addition), despite a remarkable change in the total (TA) and partial alkalinity (PA) time profiles.. On the other hand, in all the considered tests, pH modifications up to 9,5 resulted in an almost complete ammonia removal.

RECYCLING OF NUTRIENTS AND ORGANIC MATTER FROM ANIMAL SLURRIES

F.E. de Buissonjé & P. Hoeksma, Wageningen UR Livestock Research

Three good reasons for the recycling of nutrients and organic matter from animal slurry:

- the high consumption of natural gas for the production of artificial nitrogen fertilizer,
- the depletion of fossil deposits of phosphate rock in the foreseeable future,
- decreasing levels of organic matter in the topsoils of agricultural land worldwide.

Products from manure processing

Several proven techniques can be applied in order to transform the solid fraction of animal slurry into a pelleted organic fertilizer, recovering more than 80 % of the original amount of phosphate and organic matter. Other techniques are available for the production of inorganic mineral fertilizers from the liquid fraction.

The bottlenecks

The complexity and ever rising energy costs of the different techniques are increasingly restrictive for manure processing. Besides, many countries lack an adequate infrastructure system for the transportation of raw manure or manure products to the feed producing regions.

The recommendations

A lower water content of the slurry reduces the amount of energy needed for transport and processing. The water content in animal slurries can be reduced by changes in feeding-, housing- and manure collection systems. The separate collection of faeces and urine “under the tail” facilitates the processing of both streams. Sturdy and more efficient systems for manure processing and transport of products must be developed.

Nitrate Directive in the Czech Republic

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ABSTRACT

Directive No 91/676/EEC – Nitrate Directive was implemented to the Czech legislative in form of Government Ordinance No 103/2003 Coll., on vulnerable areas establishment, storage and usage of fertilizers, crop rotation and erosion control in these areas.

The first Action Program for vulnerable areas of the Czech Republic was proclaimed on 1st January 2004. Its observance and evaluation under condition of our country was till the end of 2007. Based on revision on 1st action program 50% area of agricultural land is situated in vulnerable zones/areas. *The second Action Program* for vulnerable areas of the Czech Republic was proclaimed on 1st January 2008 and *the third Action Program* for vulnerable areas will be implemented in the Czech Republic from 2012.

Central Institute for Supervising and Testing in Agriculture is entitled body for control of farming in vulnerable areas.

Table: Number of controls

	2003	2004	2005	2006	2007	2008	2009	2010 (1.9.)
Number of controls	23	50	54	54	127	184	183	136
Number of insufficiencies		13	7	5	5	14	10	13

Results from controls:

- The main risk of waters pollution is in the domain of farm fertilizers storage
- Problems with capacity and technical quality of these facilities which leads to breaking the no fertilizing period
- The problematic domain is storage of solid manure on agricultural land before its use

DIGESTATE CONCENTRATION BY MEANS OF VACUUM EVAPORATION

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In the frame of the “*RiduCAReflu*” project, financed by the Veneto Region and coordinated by Veneto Agricoltura, the most promising processes for the treatment of digestate and farming effluents are under evaluation, in the optic of complying with the *Nitrates Directive*.

Two different approaches in terms of nutrients management are considered: “destructive” and “conservative”.

The “destructive” approach is represented by processes that remove nitrogen from digestate, in the form of molecular nitrogen emitted into the atmosphere; the “conservative” methods, instead, determine the diversion of a portion of nitrogen in different fractions, easier to be managed and with higher concentration of nutrients.

Digestate concentration can be considered as one of the “conservative” processes, since nutrients are conserved in the outputs of the system, represented by concentrate and distilled water.

This technology is derived by other sectors and is mainly dedicated to the recovery of chemicals from industrial by-products. The tests are performed in a pilot-scale vacuum evaporation plant, treating the filtered fraction of digestate produced by a 1 MWe anaerobic digestion plant fed with swine manure, corn silage and other biomasses.

The inputs and outputs of the process are subject to characterization and mass and nutrients balances are determined.

DIGESTATE DRYING IN A FULL SCALE PLANT

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In the frame of the “*RiduCAReflu*” research project, financed by the Veneto Region and coordinated by Veneto Agricoltura, several processes for the treatment of digestate and farming effluents are under evaluation, in the optic of complying with the *Nitrates Directive*.

Digestate drying is a solution that can be considered as one of the “conservative” processes, since nutrients are conserved in the outputs of the system, represented by a dry organic fraction and by a solution of ammonium sulphate.

The drying of digestate is determined by an evaporation process, performed by forcing heated air through a bed of digestate, achieving the evaporation of water and the reduction of moisture content in the feedstock. The evaporation process determines also the emission of gaseous compounds, such as ammonia, so that exhaust air from the evaporation chamber must be treated prior to the emission into the atmosphere. The treatment consists of multi-stage water and acid scrubbing of the airflow.

The first full-scale plant realized in Italy, equipped with exhaust air treatment, is subject to monitoring: the inputs and outputs of the process were characterised, mass flows and energy consumption are determined and exhaust emissions are monitored. The results of the monitoring will be reported.

FULL SCALE MEMBRANE SYSTEM FOR THE TREATMENT OF DIGESTATE

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The present study is part of a comprehensive Research Project financed by Veneto Agricoltura

and the Veneto Region, Italy, with the main objective of evaluating the most relevant processes for the treatment of digestate and farming effluents, in the optic of complying with the *Nitrates Directive*.

Membrane treatment, i.e. ultra-filtration and reverse osmosis, represents a high-tech system derived from other sectors, including industrial applications and the production of drinking water. This particular type of plants represent a new solution for the treatment of digestate or manure, but the benefits that this technology offers makes it particularly promising. These plants are complex and the application of this technology to this field required intense studies and tests.

In order to verify the efficiency of these systems a monitoring campaign is conducted on full scale units treating digestate from anaerobic digestion plants. The tests are performed analysing the input and output flows, in terms of quality and quantity, with particular attention to the destiny of N and P. The present work aims to present the results of this monitoring.

COMPOSTING OF LIQUID MANURE/DIGESTATE

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In the frame of the “*RiduCAReflu*” project, financed by the Veneto Region and coordinated by Veneto Agricoltura, several processes for the treatment of digestate and farming effluents are under evaluation, in the optic of complying with the *Nitrates Directive*.

One of these technologies is represented by composting of liquid effluents, such as digestate or raw manure: a full scale system treating swine manure on a straw bed is under monitoring. The main difference from traditional composting is represented by the fact that the input feedstocks are liquid, and are spread on a bed of absorbing material (i.e. straw or wood chips) in a composting track. Aeration is performed by operating a screw type turner, equipped with air inflation system.

The tests are performed by characterizing the input streams, such as manure and straw, and by monitoring the key parameters for a composting process, such as Total Solids (TS), Volatile Solids (VS), C/N ratio, temperature and oxygen concentration. In particular, temperature is measured by means of Pt100 probes and of thermo-graphic InfraRed camera. Emissions from the compost pile are also monitored, before and after turning operations, by means of the “static chamber method” and photo-acoustic gas analyser. Mass balance and energy consumption are also assessed, in order to have an estimate of the economic aspects related to the treatment.

User experiences and economic analysis of reversal osmosis concentrate

Jitske de Hoop and Co Daatselaar, LEI-Wageningen-UR

Reversal osmosis concentrate (RO-concentrate) is one of the end products of a manure treating process. The European Union has permitted the Netherlands to use RO-concentrate as an artificial fertilizer within a pilot for the years 2009 and 2010.

Wageningen UR carries out research in the pilot among which user experiences with and an economic analysis of RO-concentrate. In 2009 the majority of the users mixed the RO-concentrate with other animal manure: it is difficult to apply pure RO-concentrate in small quantities with the allowed low emission techniques. RO-concentrate was most often applied on grassland, followed by maize and ware potatoes.

Average costs of the manure separation and reversal osmosis are estimated at around €7.50 per ton manure and sales costs, averaged over all end products, at around €3.75 per ton manure (RO-concentrate around 0). Given these costs and including the transport from the cattle farmer to the installation the cattle farmer has to pay about €15 per ton manure to make the total process break even.

Especially the application techniques and the sales costs of the end products need further research to make the whole process more attractive for both suppliers of manure and users of the end products.

Optimisation of phosphorus recycling as mineral fertiliser from piggery wastewater

Marie-Line Daumer¹, Aurélie Faucher¹, Anne-Cécile Santellani¹*

The agronomic use of pig slurry is limited by the excess of phosphorus which is mainly present as mineral solid form mixed with organic matter. Dissolution followed by a liquid/solid separation and precipitation from the liquid phase is one possibility to extract and recycle phosphorus as a product substitutable to mineral fertilisers. The precipitate is harvested directly in a filter bag used for storage and transport. For environmental, technical and economical reasons, formic acid was chosen for the dissolution and magnesium oxide for the precipitation. However, the recycling rate was limited to 50% by the decantation after acidification.

The aim of this study was to improve the separation step. Two experimental sets were conducted at a lab scale. Polymers, at different doses and separation by decantation or draining table were compared. Distribution of phosphorus, calcium and magnesium in products but also, the shape and size of the precipitated particles, were measured. Draining with polymer increased the phosphorus in solid from 50 up to 85% of the total initial phosphorus compared to the decantation with or without polymer. However, the crystals formed are smaller than those obtained after decantation without polymer and so, more difficult to separate by the filter bags.

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Nitrate leaching after different times of dairy cattle slurry application to ley in autumn and spring

Sofia Delin, Maria Stenberg and Lena Engström

Nitrate leaching was measured after application of 30 tonnes ha⁻¹ (50 kg NH₄-N ha⁻¹) of dairy cattle slurry in early autumn (September), late autumn (November) or spring (April) to first-year forage grass or grass-clover mixture ley on sandy loam in Sweden. Soil mineral nitrogen levels in December were elevated by around 6 kg N ha⁻¹ in autumn-manured treatments. Aboveground plant nitrogen was at this time about 40 kg N ha⁻¹ after early application in both ley types compared with 18 or 28 kg N ha⁻¹ in the other treatments in grass and grass-clover mixture, respectively. In April, aboveground plant nitrogen was about 10 and 5 kg N ha⁻¹ higher in the early and late autumn-manured treatments, respectively, than in unmanured treatments. Nitrate leaching during October-June amounted to 20-25 kg N ha⁻¹ in treatments with autumn application in grass-clover mixture, compared with 15-20 kg N ha⁻¹ in all other treatments (differences not statistically significant). To conclude, these first year results indicate a marked, but not statistically significant, risk of higher nitrate leaching with slurry application in autumn, especially with late application to leys containing clover.

N fertilizer replacement value of reversed osmose liquid fractions on arable land

Wim van Dijk & Willem van Geel

Applied Plant Research, Wageningen University

In the Netherlands due to restrictions on nitrogen (N) and phosphorus (P) use the animal manure surplus on a national level will increase the next years. One of the options to control the manure surplus level is manure processing resulting in liquid and solid fractions. Especially liquid fractions resulting from reversed osmose (RO) separation may be assigned as a fluid mineral fertilizer if N effectiveness and environmental impact are comparable. Therefore, in 2009 a project was started to assess the N fertilizer replacement value (NFRV) of RO-liquid fractions on arable land as well as grassland. This paper focuses on the results on arable land in 2009. Although assessing NFRV of RO liquid fractions was the main purpose, also the application of the solid fraction was taken into account. The NFRV is defined as the percentage of total N in the product having the same effectiveness as carefully applied mineral N fertilizer.

In 2009 two trials were conducted, one with ware potatoes on a marine clay soil and one with starch potatoes on a sandy soil. In both trials three RO-liquid fractions and one solid fraction were compared with the commonly used solid N fertilizer calcareous ammonium nitrate (CAN) at four N rates (0, 50, 100 and 150 kg N/ha) applied before planting. The liquid fractions were injected in the soil at a depth of 7-10 cm, the solid fraction was surface spread and incorporated. In the trials also application of liquid fractions after planting (start tuber set) were investigated. This was done at a N rate of 50 kg N per ha for liquid fractions as well as CAN. The liquid fraction was injected between the ridges at a depth of 5-6 cm. The total N content and the mineral N fraction (% of total N) of the three RO-liquid fractions varied from 5-9 kg N/ton and 89-93% respectively. For the solid fraction values were 13 kg N/ton and 42% respectively.

On both locations at all N rates marketable yield and N uptake of the potato crop on the RO liquid fractions plots were lower than on the CAN plots. For the clay soil location this effect was significant. The differences in effects of the three RO liquid fractions were small and not significant. The zero-control for the liquid fractions did not differ significantly from the zero-control for CAN indicating that negative machine effects did not occur.

Based on the response of the N uptake it could be derived that for the preplant application the NFRV of the liquid fractions was circa 75% for the clay soil location and circa 85% for the sandy soil location. Based on the composition of the liquid fractions a NFRV of 90% was expected. No clear explanation can be given for the lower NFRV values. Possibly ammonia volatilization may have played a role, although the liquid fractions were injected in the soil. When applied at the start of tuber set, the NFRV was circa 35% (clay soil) and 40% (sandy soil) being lower than for the pre-plant application.

The NFRV of the solid fraction was circa 35% (clay soil) and 50% (sandy soil) while based on the composition a value of 60% was expected.

The experiments are continued in 2010. Compared to 2009 treatments with an acidified liquid fraction and fluid mineral fertilizers were added in order to assess whether ammonia volatilization or fertilizer form are causing the lower NFRV of RO liquid fractions.

Production of mineral fertilizers from animal slurry

Paul Hoeksma and Fridtjof de Buissonjé (ASG Livestock Research)

Poster presentation at Manure Workshop, Wageningen, November 24-25

Abstract

In the Netherlands in regions with high livestock production mineral input and output are not balanced. Legal restrictions on the use of animal manure as a fertilizer force an increasing number of livestock farmers to transport manure. Transport distances and costs are increasing. Manure treatment is a way to relieve the pressure on the manure market, if from manure a solution of minerals (N and K) is produced which is qualified as a mineral fertilizer and which can be applied as such, additionally to animal manure.

During 2009 and 2010 the agricultural and environmental aspects of the production and application of mineral fertilizers from animal manure are studied in a project carried out by Wageningen UR. The project is financed by the Dutch government and agricultural business. Seven owners of treatment plants and a large number of users (arable farmers) of the end products participate in the project.

Characteristics of the seven participating treatment plants as well as the composition of the end products, a solid organic fertilizer and a liquid mineral fertilizer, will be presented.

Pyrolysis of waste organic substances and products applications

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The nitrates action plan has limited the land area suitable for the landspreading of pig manure. In addition, the main policy driver is the net reduction of atmospheric emissions of carbon dioxide, a greenhouse gas emitted mainly by burning fossil fuels. Biomass can provide a renewable and largely carbon-neutral energy source. Thermal conversion, especially pyrolysis, in which biomass feedstock is heated up to 600°C in the absence of oxygen, provides a facile procedure for the conversion of biomass into bio-oil, a biochar, and syn-gas. This technique can utilise a variety of feedstocks, which include agricultural wastes and residues, and also biomass crops, biorefinery wastes, etc. The liquid products and gases can be used to obtain energy, or can be chemically converted to give platform chemicals. Biochar, the solid residual pyrolysis product has been shown to enhance plant growth (when produced under appropriate conditions), and it is highly resistant to microbial transformations in soil. A series of analyses have established that the micro and macro elements of biochar from the pyrolysis of *Miscanthus* improve the microbiological properties of soil. However, in order to obtain the optimum value for soil applications of biochar, it is important to establish the preparation criteria that will give rise to properties that will have the desired effects. This project aims to identify effective and sustainable options that could produce renewable energy/products and biochar.



22 September 2010

*Workshop: Managing livestock manure for sustainable agriculture 24-25 November 2010:
Abstract for poster session*

More effective livestock manure managing and water protection in co-operation with farmers

More effective agricultural water protection (TEHO) -project (2008-2010) is experimenting and implementing water protection measures with local farmers in Finland. The project advisors visit all 122 participating farms and discuss about how to improve environmental aspects in their fields of production. The collected information is processed to an environmental protection handbook specific to each farm. For example recommendations for effective manure use, the nutrient balance improvement and substitute manure for commercial fertilizers in crop farms are included.

In the intensive livestock breeding areas a lot of manure has been used as a fertilizer for years. As a consequence the soil P concentration and thus the risk of nutrient leaching have increased. With the aid of GIS-data about animal farm locations the project is focusing where new measures for manure treatment are needed most. The project has carried out on-farm experiments where N and P rich components of slurry are separated with a moveable manure separator. It could be one possible solution for more targeted use of manure nutrients.

The TEHO-project is managed by Centre for Economic Development, Transport and the Environment for Southwest Finland and two regional unions of agricultural producers, and financed by Ministry of Agriculture and Forestry and Ministry of the Environment.

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(in Finnish with English
summary)



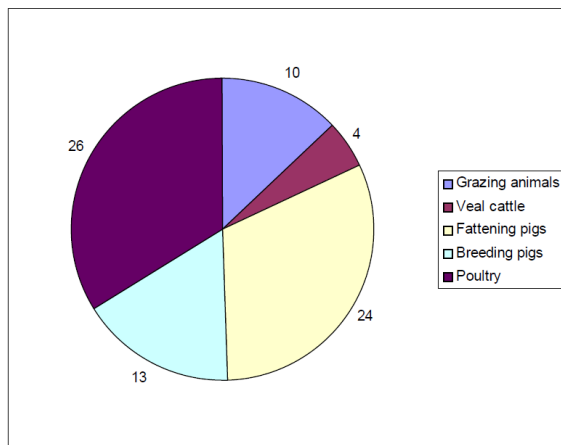
Model of Ammonia emissions and Mineral loads for policy support: MAMBO

Gideon Kruseman, Harry Luesink, Marga Hoogeveen, Pieter Willem Blokland

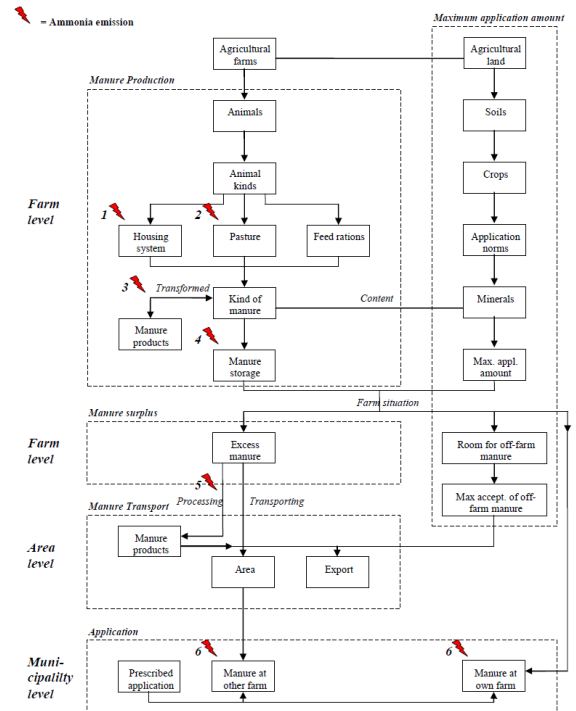
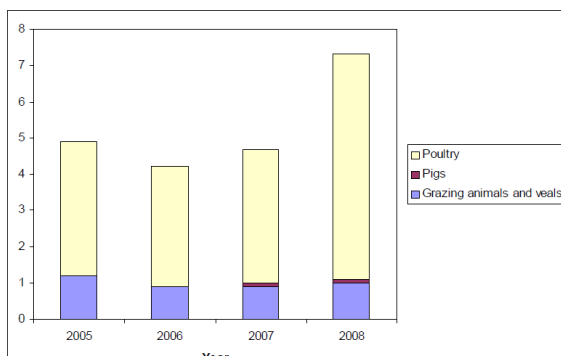
Manure market introduction

The manure market combines the supply of and demand for animal manure. The supply relates to manure which cannot be used within the system of application norms and which must therefore be disposed of by the farm. Demand comes from farms (in The Netherlands or abroad) which are willing and able to accept manure from other farms and there is demand from processing units.

Calculated supply on the market in 2008 million kg phosphate



Amount of the manure who is processed in million kg phosphate



Structure of MAMBO

Conclusions

The results who are presented are published in LEI documents and are for the Dutch situation. When the data are available the same results can be calculated for other countries. With MAMBO it is also possible to calculate the economic aspects off all kind of processing systems of manure for the whole manure market of a country.

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Nitrogen fertilizer value in the thin fraction of separated pig slurry on grassland. Preliminary results

J.C. van Middelkoop and G. Holshof
Wageningen UR Livestock Research

In the Netherlands initiatives are taken to separate animal manure into a thick fraction with mainly organic nitrogen (N) and phosphorus and a thin fraction with mainly mineral N and potassium, called "mineral concentrates". Wageningen UR has started a pilot with mineral concentrates as fertilizer, assigned by the Dutch Ministry of Agriculture. In this pilot Livestock Research carries out field experiments to establish the N fertilizer value of the mineral concentrates on grassland. The results of the experiments from 2009 are presented.

In the grassland experiments the grass yields of mineral fertilizers calcium ammonium nitrate (CAN) and diluted ammonium nitrate (AN) are compared with the grass yields of three thin fractions of pig slurry. The thin fractions are produced by ultra filtration followed by reversed osmosis. The experiment contains four fertilization levels: 0, 100, 200 and 300 kg N per ha, divided over three cuts. Two soil types are included: clay and sand.

The dry matter and N yield with the use of the thin fractions and diluted AN were lower than with the use of CAN. It is not known why the yields are lower on the plots with liquid fertilizers. Ammonia volatilization would not explain the great yield difference between CAN and AN.

ENERGY from WASTE (EfW):

A feasibility study on the economic and environmental co-benefits of biogas production within rural communities.

Declan Moroney.

Energy from waste (EfW) technologies in the form of biogas plants, CHP plants and other municipal solid waste (MSW) conversion technologies, have been gaining steady ground in the provision of energy throughout Europe and the UK. Previous studies on Centralised Anaerobic Digestion (CAD) within Ireland found that the legislative and economic conditions were not conducive to such an operation at that time.

Recent changes to the Irish REFIT tariff on energy produced from AD; alterations to the use of animal by products (ABP); the Renewable Energy Directive (09/28/EC) and a subsequent review of the draft Biowaste Directive (2001) required that the issue of decentralised energy production in Ireland be reassessed.

The feasibility study found that the policy conditions were now such, that it was technically and economically feasible for this biochemical process to provide energy and waste treatment facilities at the case study location. The study finds that the transposition into Irish Law, of the draft EU biowaste regulations, taking into consideration the proposed Irish regulations for compost, would ensure that Ireland has some of the most restrictive yet applicable regulations in Europe for the application of biowaste in agricultural agriculture. The delay in completing this piece of legislation is preventing national energy and waste issues from being resolved in a planned and stepwise fashion.



Efficient agricultural GHG emissions reduction requires a significant improvement of our knowledge on the environmental impacts of manure management

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Improved manure management is a key way forward in tackling environmental challenges in the agricultural sector, in particular water pollution and greenhouse gas emissions associated with breeding while promoting sustainable animal farming and food production.

Research carried out in Brittany (France) – where emissions due to livestock account for 22% of the total regional emissions - revealed that the current framework methodology provided by the IPCC needs to be developed further nationally to refine knowledge and evaluation of environmental impacts of livestock manure. The statistical sensitivity analysis carried out showed that the uncertainties of the results were mainly due to emissions related to manure management and in particular the storage of manure.

This has enabled us to identify key areas of research including:

- A more detailed description of the livestock manure management currently broken down in three main categories to better comprehend the diversity of manure management practices ;
- A refinement of emission factors to account better for the impacts of various manure management practices.

This could lead to better informed decision-making, knowing the most efficient manure management solutions. It could also provide more detailed and reliable report of GHG emissions including effects of policies and initiatives in a field that is far from neutral (21% of the total French agricultural emissions).

Assessment of manure and nutrient production in commercial farms: comparison of actual and standard values

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The aim of the research project carried out has been to: i) define a simplified methodology to record, manually or automatically, the main parameters of the manure management; ii) develop a software tool to process recorded data into useful information for the farmer; iii) validate the methodology and the software in practical farms.

The methodology and software tool defined are based on a simplified volume and nutrient farm balance.

Three different farms (dairy cows, fattening pigs, farrow-to-finishing pigs) has been monitored for 16 months to assess the manure management production and management obtained by recordkeeping and sensors.

The indirect evaluation of manure quantities obtained by calculations based on the recorded data gave results very close to the measured data (differences < 10%). The nutrients (nitrogen and phosphorous) produced agrees with the calculated values, but a high degree of uncertainty is introduced by the variability found in manure storages. All the three farms have reported a production of 5-10% more nitrogen than standard values.

From the results obtained it can be concluded that the devised monitoring system can be used effectively in practical farms to improve the manure and nutrient management and to assess the actual production.

FARM MANAGEMENT, NITROGEN SURPLUS, NITRATE CONCENTRATIONS AND ECONOMIC PERFORMANCE OF DUTCH DAIRY FARMS ON SANDY SOILS

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Milk production is inevitably associated with losses of nitrogen (N) that can compromise the quality of groundwater and surface water. Farm management decisions play a decisive role in the quantity of these losses. In the Dutch Minerals Policy Monitoring Program (LMM), data are collected on both farm management and water quality at farm level. In the current study, linear regression analysis was used to study to what extent nitrogen surpluses and nitrate concentrations on dairy farms in the sandy region are affected by differences in farm management.

The results show that farm management explains 67 % of the variation in nitrogen surpluses. For nitrate concentration 51 % of the variation could be explained. Decreasing the fertilization level, both in terms of organic and artificial fertilizer and increasing the yield of fodder crops have the largest effects on the nitrogen surplus. Also the nitrate concentrations were significantly affected by the fertilization level but also by other management characteristics. Management practices that increase the efficiency of manure, either by reducing the fertilization level or by increasing the yield of the fodder crops, appear to be not only environmentally attractive but also economically, as the effects on economic performance have the same direction.

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Denitrification of dairy cows manure in a closed outdoor photobioreactor

Aureliano Sinatra

October 1, 2010

Abstract

After the second mondial war the industrialization and the agriculture production succesfully have faced the increased food demand of a growing population, in a way often harmful for the environment.

The agricultural and zootechnical production is responsible of emission of a considerable amount of pollutants to both atmosphere and superficial water, with local and global impacts.

Nonetheless the european economic policies have for decades subsidized these production sectors, in the recent years a change is observed. Improved environmental laws are enforced, reduction of selling prices, increased costs of production in addiction to a continuous emigration from rural areas, pushed decision makers to find economic measure to help the rural areas.

After that the green revolution has shown his environmental limits it seems that a new paradigma is imposed from multinationals: the production of bioenergy. In the following paper it will be shown the limits and possibilities of the technology of microalgae production and a specific application of microalgae use for dairy cows waste water treatment.

A pilot plant was builded up by Entech and tested from Environment Park in collaboration with Arap, Coldiretti and Politecnico di Torino. The idea of increase the overall recovery of nutrients is the aim of "Denitren project", as a part of a regional plan of incentivation of energy recovery by anaerobic digestors and correct use of waste water managment technique. The results from pilot plant have shown an overall removal efficiency of 90% for nitrate and nitrite.

Low-tech slurry separation justifies differentiation of manure application thresholds

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Intensive livestock farms are generally not self-sufficient in terms of their feed production. Consequently they import feeds including the nutrients (N, P) that these feeds inevitably contain. This often results in local N and P surpluses because home-grown crops require less than the N and P available in the manure. To reduce the environmental pressure, these types of farms should either extensify or export their excess manure. The permitted manure rates stipulated in the current Dutch Action Programme, 40 kg P and 250 kg N per ha for most dairy farms and 35 kg P and 170 kg manure-N per ha on other farms, have strongly reduced the room for manure application and increased the need to export manure from livestock farms. Hence, intensive dairy farms are confronted with costs to export manure and to purchase additional mineral fertilizer N to compensate for this export. This stimulates further measures to reduce the excretion of N and P per unit milk or meat and to increase the amount of available N per unit applied manure P. Slurry separation is one of the methods that can increase the amount of N per unit manure P. Separation results in a solid and a liquid fraction. The solid fraction, rich in P, is less bulky and can be exported at lower costs to arable farmers. The widened N (largely ammonia-N) to P ratio of the remaining liquid fraction matches better with the requirements of forage crops. Mineral fertilizer N could thus be partly or largely substituted with liquid fraction, depending on the quality of the separation process. The overall impact of slurry treatment on permissible rates within environmental requirements will be illustrated with simulation studies. We conclude that the rate of 170 kg manure-N per ha as stipulated by the EU Nitrates Directive is unnecessarily stringent for many dairy farms. If in the form of a solid fraction, however, 170 kg manure-N per ha is linked to an amount of P that is much larger than what is taken off in harvested crops. This also applies to untreated pig slurry, for that matter. We conclude that there is a need to differentiate permitted rates to a much stronger extent unless one does not mind that regulations are too mild in one situation and unnecessarily strict in another situation.

Availability of P and K after application of ashes and biochars from thermally-treated solid manures to soil

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In areas with high livestock density it can be advantageous to export a solid manure fraction after slurry separation to avoid overload of P. By combustion or gasification of solid manure energy is produced and nutrients are concentrated and therefore less expensive to transport. However, some studies have indicated that the plant availability of P and K is decreased by combustion.

The dynamics of extractable P and K in soil was compared during 16 weeks after application of equal amounts of P in ashes, solid slurry fractions and superphosphate to a sandy soil. Concentrations of water-, bicarbonate- and resin-extractable P and exchangeable K were measured after incubation. The ashes/biochars studied derived from gasification (ca 730°C) of poultry manure, gasification of solid manure, co-combustion of solid manure with straw (ca 700 and 900°C) and pyrolysis of solid manure (250, 400 or 500°C, biochar). Resin-extractable P in soil decreased from superphosphate > solid manure=pyrolysis ash 250-500°C >poultry gasification ash>solid manure gasification ash>manure co-combustion ash.

Only 20-60% of ash K was water-soluble, but soon after application to soil 58-88% of the applied K was exchangeable compared to a KCl reference.

The heavy metal content of the tested ashes was below the Danish threshold value for wastes like ash, except for Ni in the poultry ash.

Environmental consequences of using processed manure as mineral fertilizer

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Abstract

Manure and mineral fertilizers are used in great extents in livestock production systems in the Netherlands and strongly contribute to environmental pollution. Processing of manure offers the potential to reduce this impact. The objective of this study was to compare environmental consequences of the following three scenario's concerning manure processing and management: 1. Current agricultural practice using untreated manure and mineral fertilizer (reference), 2. Application of liquid fraction from manure as mineral fertilizer, and 3. As 2, including anaerobic digestion (AD) of the solid fraction for energy production.

Life Cycle Assessment was used to asses the change in emissions from manure processing, with and without AD, compared to the reference scenario. The following emissions and non-renewable resources were included: greenhouse gases (GHG's) including, CO₂, N₂O and CH₄, ammonia (NH₃), nitrate (NO₃), particulate matter (PM₁₀), and fossil fuel depletion (FFD). The applied functional unit was 1 ton of manure input with standard composition.

Overall, processing of manure presented an opportunity to reduce GHG emissions and reduce fossil fuel depletion through a reduction of manure storage time, transport of end products after processing, and the production of renewable energy (in the case of AD). No substantial changes in emissions of ammonia, nitrate, and particulate matter were expected.

Fertilisation management and nitrate leaching in intensive Mediterranean dairy systems

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The research aims to evaluate at field scale the relationships between the agronomic management of the animal effluents and the nitrates losses in intensive Mediterranean farming systems. The experiment is carried out in a private farm with a highly intensive dairy cattle production, within the Nitrate Vulnerable Zone in the Central-Western Sardinia, Italy. This area was reclaimed in the '20ies and is characterized by a shallow water table and sandy soils. The field activity, started in 2009, is based on monthly monitoring of the nitrates concentration measured by piezometers and porous cups and soil water content by tensiometers, in relation to four N fertilization sources (NVZ: 170 kg N ha⁻¹ year⁻¹ of slurry + mineral fertilizer; Mi: 100% mineral N fertilization; S: 100% slurry; Ma: 100% manure), in an irrigated rotation silage-corn - ryegrass, which is one of the most important irrigated cropping systems in the area. Crops yield and the N content of harvested biomass and crop residuals are also measured. Farming practices are analysed by systematic interviews to the farmer. The results of the field scale analysis are used to calibrate and validate a simulation model of cropping systems to forecasting N leaching in Mediterranean intensive cropping systems.

Matching N and P₂O₅ crop requirements using separation products of cattle slurry

Koos Verloop, Gerjan Hilhorst

Dairy farmers commonly use artificial fertilizers in addition to farm slurry to meet crop nitrogen (N) and phosphorus (P) requirements. The N and P requirements depend of the crops used and soil P-status. Hence, the ratio of N/P required is variable. It is hard to meet these requirements with only farm slurry because its N/P ratio is more or less fixed. Mineral fertilizers are used to correct for this. The question is to what extend the use of mineral fertilizers can be reduced by separating farm slurry in a liquid fraction high in N/P-ratio and a solid fraction low in N/P-ratio.

On experimental dairy farm De Marke we quantified the N and P requirements for each of the fields of the farm. Next, we calculated the optimal distribution of slurry, liquid fraction and solid fraction over the fields. The result was tested in practice on feasibility.

The mismatch between the needs of the fields and the applied fertilizers by slurry could roughly be halved by separating part of the slurry. The N/P-ratio of the liquid fraction was too low to meet the requirements in permanent grassland completely.

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