TIPPERARY MILLING COMPANY LTD

APPENDIX NO. 2

COPY OF RESPONSES
TO
AN BORD PLEANALA

JULY 2010

NRGE LTD

Tipperary Milling Co. Ltd.

Response to An Bord Pleanala.

(PL 22.226891 ; P.A. Reg 07/51/0108.)

Dated 19th Nov. 2008

Nutrient Recovery to Generate Electricity

Mooresfort,
Lattin,
Co Tipperary,
Tel 062 55385
Fax 062 55483
E-mail NRGE@iol.ie

ME FRANK DEMPSEY
EXECUTIVE OFFICER
AN BORD PLEANALA
64 MARLBOROUGH STREET
DUBLIN 1

19 November 2008

RE: PLANNING APPLICATION TO NORTH TIPPERARY COUNTY COUNCIL BY Tipperary Milling Company Ltd, for the construction of a Primary and Secondary digester with gas holder, a gas purification system, 4 No Feedstock storage tanks, Hot water storage tank, Five span shed as plant house, 2 No pre mix concrete reception tanks, 2 No covered engineered storage basins, 2 No Grain stores, Fibre store , Weighbridge, entrance and associated site works, to process pig manure and other associated organic material to produce renewable energy and fertilizer (E.I.S. submitted). This development comprises of an activity in relation to which a license under Part IV of the new First Schedule to the Environmental Protection Agency act 1992 as amended by Protection of Environment Act 2003, is required, at Ballaghveny, Ballymackey, Nenagh, Co Tipperary.

YOUR REF 07/51/0108

Dear Mr Dempsey

We herein acknowledge receipt of yours dated 22nd August 2008, requesting the submission of additional information in support of this planning application lodged on behalf of Tipperary Milling Company Ltd for Planning Permission as outlined above. As stated this application will not increase the capacity of the associated pig farms, but will improve the environmental performance of both facilities by greatly reducing emissions.

Nutrient Recovery to Generate Electricity Ltd is registered at Mooresfort, Lattin, Co Tipperary Company Reg. No 392619

In our view this is a project which has potential to create a template, which can be copied throughout Ireland, ensuring sustainability of existing intensive agricultural operations, while at the same time reducing their associated environmental impacts, by centralised anaerobic digestion. The treated animal manures and other organic material, result in a liquid digestate, which is recovered as a fertilizer on agricultural land, to produce crops, which in turn feed the animals, which produce the manure. The excess heat from the gas engine, will be utilised to dry the grain in the adjacent grain stores, displacing further fossil fuel use, and the resultant green energy can be sold to the electricity network.

This type of project has serious potential nationally, to help compliance with our national environmental commitments, such as CO2 emission reduction requirements, Kyoto commitments, and commitments for reduction of organic materials to landfill. Additionally in this time of serious stress in the employment markets, this type of project has potential to provide employment for up to 8000 people throughout Ireland if was allowed to develop, over the next decade, as it has in the past decade in Germany.

A collective national responsible approach must be taken by all stakeholders to ensure compliance with the international commitments referred to above, by means of development of sustainable projects, environmentally and economically, or the resultant penalties, which effectively commence late 2009, will place unbearable pressure on the already strained national reserves.

During the planning and design phase of this proposed development NRGE Ltd engaged extensively with our international associates, who have between them extensive experience in several continents, over the past 3 decades. Our main associate is Mr Lars Baadstorp, who has operated as a consultant, contractor, and manager of anaerobic digesters, in four continents, over the past 25 years. We have included a report from him in Attachment 1.

In addition we must clarify that prior to the preparation, and submission of this planning application, Mr Tim Cullinane, as a Director of Tipperary Milling Company Ltd, visited all stakeholders, within a 1 mile radius of the proposed development, outlining his plans, and offered all an opportunity to view the full application, including the supporting Environmental Impact Statement, prior to its submission. In addition a number of public meetings were organised for any interested stakeholders, to come and view a detailed presentation of the proposed development, including a specific one for all elected representatives in the area.

These meetings were well attended and it must be said that the response was very positive, including from the current objector, at that time. It was generally accepted by all that the re-development of the associated pig fattening unit, and the proposed development of the anaerobic digester, would result in an improvement of the current situation. The redevelopment of the pig farm, would partly aid the reduction of emissions from the site, but the development of the anaerobic digester would greatly reduce emissions by regular removal of pig manure from both associated pig farms, and following treatment. by reduction of emissions from the application to land.

Following this intensive round of meetings, and discussions with interested stakeholders, all concerns, and recommendations raised were incorporated into the planning application. to the extent that all parties, including the current objector, indicated that they were happy with the proposed development, and would not be objecting.

However we will now proceed to respond to your queries. The issues raised in your correspondence are responded to in the same numerical format.

1. **THE BORD HAS CONCERNS THAT THE E.I.S. SUBMITTED IN SUPPORT OF THIS PLANNING APPLICATION IS DEFICIENT WITH RESPECT TO ITS ASSESSMENT OF THE RECEIVING ENVIRONMENT AND THE POTENTIAL IMPACTS OF THE PROPOSED DEVELOPMENT WITH REGARD TO HUMAN BEINGS (LOCAL RESIDENTS) AIR QUALITY (INCLUDING ODOUR), NOISE AND PROTECTION OF GROUNDWATER AND SURFACE WATER (WHERE THESE RELATE TO THE SITE AND ENVIRONS).**

1. INTRODUCTION

In response to this comment we must firstly, and clearly point out that the purpose of this planning application for an Anaerobic Digester facility at this location, was to ensure compliance with environmental regulations, for the 2No. Associated pig farms currently operating on sites adjacent to this proposed development. These two associated pig farms are currently operating with the full benefit of planning permission, and producing 26,000 M3 of pig manure annually, which is recovered on local customer farms, in accordance with S.I. No 378 of 2006. These two existing pig farms, and this proposed AD development are currently all included in the review of an existing IPC License. This review is currently being carried out by the Environmental Protection Agency in accordance with Section 90(i)(b) of the EPA Acts 1992 to 2007, as IPPC Reg No P0467-02.

An IPC License was issued by the Environmental Protection Agency on 29th March 2000 (Reg No P0467-01), for one of these pig farms, which is now a specialised breeding unit, located at Woodville Ballymackey, Nenagh, Co Tipperary, which contained a condition to carry out an "Investigation of the possibility of alternative treatment technologies such as digestion for the disposal of slurry", and to report on same to the Agency.

The second pig farm is located at Ballyknockane, Ballymackey, Nenagh, Co Tipperary, which was purchased recently by the Woodville pigs Ltd, and operates as a specialized finishing unit for the progeny from their breeding unit at Woodville.

1.1 BACKGROUND

NRGE Ltd were engaged by Mr Tim Cullinane in December 2005, to investigate the possibilities of alternative treatment technologies, for his two pig farms, to review his current operational procedures, to undertake a feasibility study, design the necessary facilities, and prepare planning applications, and IPPC License applications as required.

This review of current operational practices and procedures, identified the main environmental impacts from the existing operations as

1. Emissions from the Pig Farms to Air, potentially effecting local residents, and Air Quality
2. Emissions from associated land application of pig manure to customer farms, potentially effecting local residents, and Air Quality.
3. Use of old animal houses on the fattening site, with large open yard areas collecting rain water into slurry channels, and tanks, with no leak detection systems.
4. Use of large open slurry storage systems for pig manure on the Fattening unit, with serious emission peaks during periods of extended storage, and agitation, potentially effecting local residents, and Air Quality
5. Use of fossil fuels on both farms to provide heating within the animal housing, resulting in emissions effecting Air Quality.

1.2 PROPOSAL

NRGE LTD, also identified the landfill facility at Ballaghveny Landfill, which operates under EPA licence 0078-02, as an adjacent significant emission facility, which by way of its boundary being within 100m of the Pig breeding unit at Woodville, had to be classified as a stakeholder. As a result discussions, and negotiations, were entered into with North Tipperary County Council, in March 2006, which ran until December 2006, to investigate the possibility of a joint venture. A suitable site was identified within the boundary of the landfill site for a joint venture Anaerobic Digester to treat pig manure and other organic materials, and to take the landfill gas, from the landfill gas extraction system, which was in construction at the time, to mix it with the gas from the animal manure and organic mix, and to burn the mix in the gas engine. However by December 2006 it was clear that no progress was being made, and the project was moved forward on the current site. The proposed development of an AD facility at the current site at Ballaghveny, is the main the component proposed by NRGE Ltd, to help resolve the environmental impacts identified above.

1. Emissions from the pig farms to Air, potentially effecting local residents, and Air Quality, can be reduced by up to 50% by means of regular removal (every 2-4 weeks) from the pig manure storage tanks, to be delivered to the proposed AD facility.
2. Emissions from associated land application of pig manure to customer farms, potentially effecting local residents, and Air Quality, can be reduced by 80%, by application of liquid digestate to land after treatment in the proposed Anaerobic Digester at this site.
3. Use of old animal houses on the fattening site, with large open yard areas collecting rain water into slurry channels, and tanks, with no leak detection systems. This issue was resolved by means of a separate planning application, for which permission was granted, on 26th August 2008. The construction of these new animal houses is well underway, with independent leak detection systems, proving the developers commitment to reducing environmental impacts, while at the same time improving welfare conditions for animals and staff alike on site, as well as improving feed efficiency. It is also worthy of note that an improvement on feed efficiency, is an additional means of reduction of environmental impacts, by way of less transport emissions, and lower general emissions per kg pig meat produced, from feed production, transport, etc.
4. Use of large open slurry storage systems for pig manure on the Fattening unit, with serious emission peaks during periods of extended storage, and agitation, potentially effecting local residents, and Air Quality. This issue has also been resolved by means of a separate planning application, for which permission was granted, on 26th August 2008. This work has already

commenced on site, again proving the developers commitment to reducing environmental impacts.

5. The use of fossil fuels on both farms to provide heating within the animal housing, resulting in emissions effecting Air Quality, can be entire replaced by utilization of the heat generated at the proposed AD facility.

In the Environmental Impact Statement, submitted in support of this planning application, we discussed the proposed reduction of Air Emissions, in section 3.4.2., wherein we identified and discussed the

" ***Proposed Measures to further Minimize and Abate Odour on site, as***

1. *All pig manure will be delivered fresh to the anaerobic digester, thereby greatly reducing emissions from under floor storage tanks. The fresher the pig manure is delivered to the digester the greater the gas production levels that will be achieved. Removal of pig manure regularly from the storage tanks under the pig houses will effectively qualify these houses as low emission housing. This process is described in detail in a document that is publically available on the internet, at* *http://www.infomil.nl/luch/index.htm.*
2. *The odour impact of land application of liquid digestate vv pig manure will be reduced by 80% approx. based on studies undertaken in Denmark on the actual application of liquid digestate replacing pig manure applications.*
3. *The development of the anaerobic digester will negate the requirement of agitation of raw pig manure in open storage tanks. Odournet UK Ltd who have acted as the Agency's experts on a number of sites to date have referenced in a report prepared for another pig farm that "The specific emission rate of an open storage tank, is assumed to increase from 150 ouE $m^{-2} \cdot s^{-1}$ to 500 ouE $m^{-2} \cdot s^{-1}$, when the slurry is being agitated" this is stated in page 10. Section 2.2, of a report prepared by Odournet UK titled* ***'Review of Odour impact of two pig production units and options for improvement'.***
4. *All pre mix tanks and storage tanks on site will be covered. All materials entering this proposed development will be immediately transferred into the concrete circular mixing tanks, or the overground PVC coated insulated stainless steel tank.*

The nett result of this proposed development will be a major reduction of the current level of emissions from the associated pig farms, in the order of at least 50%, and the resultant land application operations, in the order of 80%."

The fact that the digestate is to be separated following treatment in the proposed anaerobic digester, will result in 70/80% if the phosphorus being removed in the fibrous portion, which will most likely be used in application to land with specific high P requirements, or used in non-agricultural outlets, such as nurseries or composting facilities. This will greatly reduce the risk of excess phosphorus leaching to surface and ground water.

In addition to the elements already outlined, a tank and pipeline integrity programme will be put in place on all sites, which will incorporate the monitoring of ground water wells adjacent to the site, both up-gradient and down-gradient, in compliance with the requirements of the IPPC Licence currently being reviewed by the EPA.

1.5 ODOUR REDUCTION BY ANAEROBIC DIGESTION

The main odours experienced by stakeholders in the area is the result of land application of pig manure to agricultural land. The anaerobic digestion process reduces some of the components that normally cause odour when spreading manure. Experience is that the smell is reduced and it does not linger. This is achieved by the reduction of most pugnant volitile fatty acids in the Digestion Process, as per the chart below.

Compound	Iso-butanoic Acid	Butanoic Acid	Iso-valeric Acid	Valeric Acid
Concentration in Raw Manure (mg/l)	420	890	600	220
Concentration in Digested Manure (mg/l)	90	20	120	undetectable

* Source: Environmental effects of anaerobic digestion and separation of slurry - odour, ammonia emission and nitrogen utilisation J. Grøn Viden, Markbrug no. 296. (in Danish only) Dep. of Agricultural Engineering, Danish Institute of Agricultural Sciences **

In each of the examples there is a greater than 80% reduction in the compounds.

In addition a further reduction of odour during application to land from digested and separated Digestate compared with raw manure is the lower viscosity of the digestate runs quickly from the surface of any foliage because there are little solid particles to maintain the Digestate on foliage, which provides this project with the targeted reduction of odour emissions from the land application activities of liquid digestate, rather than the current practice of application of raw pig manure. See published papers included in Attachments 2 and 3.

1.6 DESIGN OF ANIMAL HOUSING SYSTEMS

During the design stage of this proposed development all BAT documents were referenced to ensue the optimum designs were utilized. The relevant abstracts from Integrated Pollution Prevention and Control (IPPC) Reference Document on Best Available Techniques for Intensive Rearing of Poultry and Pigs November 2002 produced by EUROPEAN COMMISSION DIRECTORATE-GENERAL JRC JOINT RESEARCH CENTRE Institute for Prospective Technological Studies (Seville) Technologies for Sustainable Development European IPPC Bureau, showing examples of low emission housing and methodology for minimising odour, are included in Attachment 4.

We have also included therein Section1.4.1 (Emission to Air), and 1.4.2 (Emissions to Soil, groundwater, and surface water). The emissions to air are defined as

Ammonia (NH_3)	Animal housing, storage of manure and landspreading of manure
Methane (CH_4)	Animal housing, storage of manure and manure treatment
Nitrous oxide (N_2O)	Animal housing, manure storage and landspreading
NO_x	Heaters in buildings and small combustion installations
Carbon dioxide (CO_2)	Animal housing, energy used for heating and transport on farm, burning Of waste
Odour (e.g. H_2S)	Animal housing, storage of manure, landspreading of manure
Dust	Milling and grinding of feed, feed storage, housing of animals, solid manure storage and application
Dark smoke/CO	Burning of waste

Table 1.6: Emissions to air from intensive livestock production systems

Having reviewed this document, the following decisions were made for the project

1. The optimum design of fully slatted pens over shallow tanks, to be regularly released to separate covered storage tanks was selected for the associated fattening unit.
2. Anaerobic digestion offered best option to reduce land-spreading emissions, and satisfied Bat as there is a large energy requirement on site, and large heat requirements on site.
3. CO2 emissions from the animal housing would be reduced with the housing design, and on site greatly by displacement of fossil fuelled heating on site.
4. Ammonia (NH3) Methane(CH4), and Odour emissions would be reduced by this house design, and use of covered manure storage systems, but also greatly by land-spreading the resultant digestate rather than raw pig manure.

1.7 AIR DISPLACED FROM FEED STOCK STORAGE TANKS ON SITE

The proposed development includes a number of feed stock storage tanks. Four of these are vertical over-ground tanks which will be equipped with external 100mm diameter fixed filler pipes connected to the top of the tank as per drawing No 004 submitted with the planning Application. These tanks have a capacity of 50 M3 and are suitable for liquid type waste fatty streams which have a relatively low viscosity when warm or oily type streams which will be in accordance with the approvals from the Animal By-products Section of the Department of Agriculture. Filling of these vertical tanks will be by positive displacement pump fitted to the delivery vehicle and a flexible pipe to couple to the fixed filler pipe. The air displacement from within the tank will equate to the volume of feedstock delivered maximum 27m3 and this will disperse quickly. An isolating valve and coupling cap will be fitted to the fixed filler pipe and remain closed when the tank is not being filled.

The underground feedstock tank is a concrete constructed tank with an infill hopper and concrete apron in front of it so that vehicles delivering more solid type waste streams such as belly grass and flotation sludge can tip directly into the hopper. The intake hopper will be maintained under negative pressure by a 300m3/hr fan capable of 3 air changes per hour and exhausting the air through a bio filter located on top of the mix tank. The intake hopper door will close the contacts on a limit switch activating the air extraction fan. Locating the fan on the mix hopper and its activation only when the hopper door is open reduces the size of fan required also the energy consumption to effectively aspirate the mix tank.
The arrangement of the tank, intake and biofilter are shown in attached drawing no 303included in Attachment 5.

1.8 FACILITY MANAGEMENT PLAN

A HACCP Plan has been developed has been prepared for this proposed development and a full copy of same is included in attachment No. 6. This sets out clearly the management measures and procedures to be undertaken on site on an on-going basis to ensure the proper management and operation of this facility, in accordance with best practise in similar type operations throughout Europe. This plan was prepared in association with ouf experts such as Mr. Lars Baadstorp, (C V included in attachment no. 1)

1.9 PROCESS CONTROL SYSTEM

A full process control system (SCADA) is included in Attachment No. 7. This report has been prepared by our Associates who have twenty five years experience in the anaerobic sector. It is based on the professional management systems currently operational on similar anaerobic digestion facilities throughout Europe. It details the type of system software, reporting, alarm systems, data exchange and functional systems required to operate a facility such as the proposed development. This expertise is available to the management and operators of the proposed development, at local and remote levels.

2. **The Board has concerns that the proposed site entrance design may constitute a traffic hazard, in particular whether adequate stopping sight distances are available with respect to traffic turning into the facility from the local road network. The applicant is invited to submit revised proposals in this regard, detailing the proposed entrance design and any necessary road improvement measures needed to ensure that access and egress from the facility for HGVs and other vehicles can be achieved safely. Information proved should be prepared by suitably qualified and experienced persons and be supported with the necessary mapping/diagrams.**

A full response has been prepared by M & J Mc Eniry, Engineers titled "Assessment of the proposed entrance to the proposed biogas plant at Ballaghveny, Ballymackey, Nenagh, Co. Tipperary. This report is included in full in Attachment No. 8.

In conclusion we respectfully request that a positive decision be made in granting permission for this proposed development, which in our view offers an opportunity for a pro-active development, which will satisfy a number of critical national requirements at this time.

1. Provide security for jobs in the intensive agricultural sector.
2. Reduce environmental impacts from existing operations.
3. Reduce emissions from current land-spreading activities.
4. Reduce emissions from existing facilities.
5. Generate green energy (electricity and heat)
6. Replace fossil fuel for heating on existing units.
7. Provide high quality fertilizer for customer farmers displacing imported chemical fertilizer.
8. Provide additional employment in rural Ireland.
9. Provide a sustainable environmentally friendly, economically viable locally sustainable production cycle, which complement each other, while minimising emissions.

I trust that this submission meets with your approval.

Yours Sincerely

Michael Sweeney
Director

Michael Mc Eniry
Director

N.R.G.E. Ltd.
Nutrient Recovery to Generate Electricity Ltd.
Mooresfort, Lattin, Co. Tipperary.
Tel: 062 55385
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ATTACHMENT NO. 1

REPORT FROM MR LARS BAADSTORP

Michael Mc Eniry

From: Lars Baadstorp [lars.baadstorp@planaction.dk]
Sent: 20 November 2008 11:45
To: Michael Mc Eniry
Subject: Odour
Attachments:

Michael

Hereby a statement:

"It can be stated that the odour from land spreading of digested and separated manure is much lower than from spreading of raw manure. The positive impact of digestion and separation of manure can be located in two ways:

* The odour of the digestate and the separated manure is much lower than in raw manure due to degradation of odoriferous substances such as organic acids and mercaptanes. The odour impact of spreading digestate and separated digestate is that there will be an odour only in a short distance (normally less than 100 m) from the field where the spreading takes place

* The odour from the digestate and the separated digestate will disappear shortly after spreading because is smells less (see above) and because it soaks down in the grown rabidly because of it low dry matter content/high viscosity.

The result is a slight odour on the field and less than 100 m away during spreading and that this odour is gone after approx. 2-4 hours. The odour pressure from land spreading of digestate and separated digestate is therefore substantial lower than from spreading of raw manure."

PlanAction

Lars Baadstorp

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Curriculum Vitae

Name: Lars Baadstorp

Year of birth: 1954

Position: Director

Education
1981: M.Sc (geography), University of Aarhus, Denmark

Occupation

2007 -

Plan*Action*
Director
Independent consultant
Planning and realising of biogas and other bio energy projects
Project development, organisation, financing, tendering, action plans
Environmental Impact Assessments, applications.

2004 - 2007

Xergi A/S
Turnkey contractor biogas and separation plants
Project Development Manager, development of international biogas projects
Specifications as for Dansk Biogas below

2001 - 2004

Dansk Biogas A/S
Turnkey contractor, biogas and separation plants
Project Manger

Project development and planning

- International biogas projects.
- Planning of biogas and separation plants for agriculture
- Treatment of organic waste from industries and households
- Feasibility studies for biogas and separation plants
- Applications for planning permission, environmental permissions etc.
- Project organising and finance
- CDM projects
- Planning of utilisation of digestate as fertiliser

1984 - 2001

NIRAS Consulting Engineers and Planners
Project Manager

Energy, environmental and resource planning

- Biomass for energy supply
- Heat and energy planning
- Mapping of biomass resources

- Planning and organising of district heating
- Feasibility analysis
- Utilisation of digestate as fertiliser

Implementation of energy projects
- Biogas plants (joint installations and on farm installations)
- District heating based on bio energy and natural gas
- Project management
- Organising and financing energy projects

R&D projects
- Modular and standardised biogas plants
- Standardised energy plants for smaller towns
- Tools for mapping of bio energy resources
- Systems for energy savings

1982 – 1983: Northern Jutland Council, The Planning Office
Regional planning
- Revision of regional development plan for Northern Jutland Council
- Recommendations for the Council in relation to Regional Planning

1978-79: The Ministry of Environment, Planning Department
- National Town Pattern

Selected References

2008: Planning of a biogas installation near Bogense, Denmark for treatment of manure and separated manure and for supply of gas to Bogense District Heating Company. Client: Farmer Group and Bogense District Heating, Denmark.

Economical assessment of installation of a large scale farm biogas plant at a large dairy farm at Fyn, Denmark. Client Carsten Hedegaard, Denmark

Assessment of utilisation of chicken manure for energy and fertiliser production. Client: DanHatch, Denmark

Project development of installation for pre-treatment of chicken manure and other nitrogen rich biomasses for biogas production. Client: ECOS, Holland

Preparation of finacila close for a large scale plant in Bieganow, Poland. Client: SymEnergy, Poland

Feasibility study for a biogas installation for manure, energy crops and industrial waste including fertiliser management in Devon, UK. Client: Clinton Devon Estate, UK.

Feasibility study for a biogas installation in Cavan, Ireland for treatment of organic waste (slaughterhouse waste, house hold waste, industrial waste etc). Client: Oxigen/Shanahan Engineering, Ireland

Feasibility study for enlargement of the biogas plant in Filskov, Denmark, Client: Filskov Energy Company, Denmark

2007: Feasibility Study for a biogas installation for manure and waste products at Viotia, Greece. Client: CRES, Greece

	Feasibility Study for biogas plants in Veendam and Coevorden, Holland. Client: ECOS, NL
	CDM biogas projects in South East Asia (biogas on Palm Oil Mills). Client: CST, Malaysia
	Feasibility Study for biogas plant for slaughterhouse waste, Cavan, Ireland.
2004:	Feasibility Study for biogas plant for treatment of restaurant waste in Japan. Client: SANWA Engineering, Japan
	Establishment of a sales and project development organising in Ireland. Client: Internal/NRGE Ireland
	Feasibility Study for joint biogas plant Grønhøj, Denmark. Client: Grønhøj Biogas
2003:	Feasibility Study for joint biogas plant at Mors, Denmark (including pumping of manure from the farms to the plant and back to the fields). Client: Morsø Biogas
	Investigations for a large-scale farm based biogas plant in Thailand (Karoon Farm). Client: Karoon Farm/DANIDA
2002:	Application for permissions on more farm based biogas installations. Client: More biogas Projects.
	Implementation of a partnership with a Malaysian and Thai enterprise. Client: Danida
2001:	Project maturing of Odder biogas, Denmark. Client: Odder Biogas/Ministry of Energy, Denmark
	Feasibility Study Ringsted Biogas. Client Ringsted Biogas/Ministry of Energy, Denmark
	Feasibility Study for biogas plants on large-scale pig farms in Poland. Client: Poldanor/Ministry of Energy
2000:	Plan for implementation of large-scale farm/slaughterhouse based biogas plants in Greece. Client: EU
	Feasibility Study Odder biogas. Client: Odder Biogas/Ministry of Energy
	Feasibility Study for bio energy plant for MSW in Norway including utilisation of nutrients for production of energy crops. Client: Anafab AB, Norway
1999:	Application for permission and organising of a joint biogas plant in Holsworthy, UK. Client: Holsworthy Biogas, UK
	Project for manure management and biogas in Cantabria, Spain. Client: EU
	Detailed project for biogas plant for slaughterhouse waste. Client: Hind Agro, India.
1998:	Feasibility Study for biogas plant for MSW in Borculo Neede, Holland. Client: LectriGas, Holland

Training actions in relation to biogas, biogas planning and implementation for leading officials and decision makers in Portugal and Greece, Client: EU

Feasibility Study for biogas plant in Fivemiletown, Northern Ireland.
Client: Ulster Agricultural Organising Society Ltd

Implementation of joint biogas plant in Vaarst-Fjellerad.
Client: Vaarst-Fjellerad Biogas.

1997: Assessment of a biogas plant for MSW in Helsingør, Denmark in relation to reconstruct the plant.
Client: Nordsjællands Biogas, Denmark

Training Action in relation to biogas, planning and implementation of biogas plants for India officials and decision makes. Client: Ministry for Renewable Energy, India

1996: Project Management for implementation of a joint biogas plant combined with wood chip combusting and new district heating system for approx. 180 households in Blåhøj, Denmark.
Client: Blåhøj Energy Company

1995: Project Management for implementation of a joint biogas plant combined with wood chip combusting and new district heating system for approx. 320 households in Snertinge, Særslev and Føllenslev Denmark.
Client: Snertinge, Særslev, Føllenslev Energy Company.

Planning, application for permission and plan of finance for Blåhøj Biogas, Denmark.
Client: Blåhøj Biogas

Planning, application for permission, organising and plan of finance for natural gas fired CHP plant and new district heating system in Skuldelev, Denmark. Client: Citizen group

1994: Project Management for implementation of a joint biogas plant in Filskov combined with wood chip combusting and new district heating system for approx. 160 households, Denmark.
Client: Filskov Energy Comapny.

1993: Planning, application for permission, organisation and plan of finance for biogas plant combined with wood chip combusting and new district heating system for approx. 320 households in Snertinge, Denmark.
Client: Snertinge, Særslev, Føllenslev Energy Company.

1992: Implementation of a joint biogas plant combined with wood chip combusting and new district heating system for approx. 140 households in Hodsager, Denmark.
Client: Hodsager Energy Company

1991: Planning, application for permission, organising and plan of finance for joint biogas plants combined with wood chip combusting and new district heating system in Hodsager and Filskov, Denmark. Client: Citizen groups and Ministry of Energy, Denmark

1990: Development of standardised and modular build biogas plants.
Client: Ministry of Energy, Denmark

Planning, application for permission, organising and plan of finance for wood chip fired plant and new district heating system in Østløs, Denmark. Client: Citizen group

Other

Board member in Danish Biomass Association (Chairman 2000 – 2004)

Invited speaker in international conferences in: Norway, Sweden, Finland, UK, Ireland, Latvia, Germany, Poland, Holland, Belgium, France, Austria, Spain, Greece, Rumania, USA, Brazil, India, Japan and Thailand.

Language

Engelish:	Reading, speaking and writing:	Perfect
German:	Reading, speaking:	Perfect
	Writing:	Fair

ATTACHMENT NO. 2

PAPER PUBLISHED BY DANISH INSTSTUTE OF AGRICULTURE

Effects of separation and anaerobic digestion of slurry on odour and ammonia emission during subsequent storage and land spreading

M.N. Hansen[1], and T. Nyord[1], [1]Danish Institute of Agricultural Sciences, Department of Agricultural Engineering. Research Centre Bygholm, P.O. Box 536, DK-8700 Horsens. Phone: 89993036, MartinN.Hansen@agrsci.dk.

ABSTRACT

A study was set up to investigate the environmental effects of anaerobic digestion and separation of slurry. Volatilisation of odour and ammonia from treated and untreated slurry were compared both during storage and following band spreading. Storage losses of ammonia were found to be higher from uncovered stores of anaerobically digested and separated slurry than from untreated slurry; however, when slurry stores were covered by an artificial crust of LECA pebbles, storage losses were decreased to low levels for both treated and untreated slurry. Ammonia volatilisation following landspreading was lower from both anaerobically digested and separated slurry compared to untreated slurry. Treatment of slurry by anaerobic digestion and separation did not reduce odour concentration in headspace air above slurry stores; however, odour concentration above slurry stores was efficiently reduced by an artificial crust cover of the slurry stores. Odour concentration in air sampled above landspread slurry was reduced by 17% and 50% by anaerobic digestion and by combined anaerobic digestion and separation respectively.

INTRODUCTION

Storage and handling of slurry may lead to considerable environmental impact in the form of ammonia volatilisation and odour nuisances. Ammonia volatilisation leads to reductions in the nutrient value of livestock manure as well as it may have a negative affect on the aquatic environment and on vulnerable natural areas (Portejoie et al., 2002). The odour nuisances of manure management injure the reputation of the farmers on a local as well as on a national basis. Ammonia and odorants are emitted from slurry in the form of gases generated in the slurry, and the extent of the emission will therefore largely depend on composition and handling of the slurry. This has lead to a considerable interest in how recent handling technologies like anaerobic digestion and separation of slurry effect emission of ammonia and odour during storage and land application of slurry.

The principle of mechanical slurry separation by means of a decanting centrifuge implies separation of slurry into a dry matter fraction (fibres) and a considerably greater liquid fraction (liquid). The fibre fraction will normally be piled in the field for later use within plant production. The liquid is usually stored and applied the same way as ordinary slurry, but once it is separated, the viscosity of the liquid will be lower than unseparated slurry because of lower dry matter content (Møller *et al*, 2002). The same effect is observed by anaerobic digestion of slurry, which is performed to utilise the energy potential of slurry in form of production of methane (biogas). During the anaerobic digestion, slurry dry matter and some of the odorous components of the slurry is degraded (Pain *et al*., 1990). The slurry will thereby become thinner. The lower viscosity of slurry liquid will increase the infiltration of the liquid following landspreading and thereby reduce the time the slurry will be exposed to volatilisation of ammonia and odorants (Vandré *et al*., 1997).

On the basis of that a study was set up to compare emission of ammonia and odour from untreated, anaerobic digested and separated slurry during storage and landspreading.

MATERIALS AND METHODS

Prior to the investigations, the following technologies were used for treatment of freshly produced pig slurry: untreated (Untreat), anaerobic digestion in a mesothermophilous digestion unit (AD), solid-separation by a decanting centrifuge (Sep), and anaerobic digestion and solid-separation by a decanting centrifuge (AD-sep).

Following treatments 30 t of each slurry type were stored four months under equal conditions during which ammonia loss and odour emission rates for each type of slurry were determined. The ammonia loss and the odour nuisances from the different slurry types were further determined in connection with landspreading. All experiments were performed both in 2002 and 2003. The ammonia loss during storage was measured by way of mass balance determination of the nitrogen content in the slurry before and after storage. The ammonia volatilisation rates following slurry application in spring barley were determined for each slurry type by applying 30 t of slurry per ha by means of trailed hoses onto a number of 36 × 36 m test field sites. The ammonia volatilisation from each site was determined by use of the micro-meteorological mass-balance technique (Leuning *et al*, 1985). Besides, loss of nutrients during storage of the fibre fraction was determined by means of a dynamic chamber technique (Osada and Fukomoto, 2001).
The relative odour emission from stores of the differently treated slurry types were determined by covering the slurry stores with a plastic shed for periods of 20 minutes, after which air samples were taken in the headspace above the slurry surface. The odour concentrations in the air samples were then determined by dynamic dilution olfactometry. The procedure was repeated immediately after the slurry was stirred. The odour emission following slurry application was determined by placing a static air chamber over the applied slurry 0 and 240 minutes after the slurry application. The emitted odorants were then accumulated in the air chamber for 20 minutes, after which a number of air samples with a volume of 30 l were taken. The odour concentrations in the air samples were then determined by dynamic dilution olfactometry.

RESULTS AND DISCUSSION

Table 1. Year of experiment and classification of tested slurry types

Year	Slurry type	Dry matter, %	pH	Total N, kg t^{-1}	NH_4-N, kg t^{-1}
2002	Untreat	3.4	7.4	4.3	3.1
2002	AD	3.2	8.1	5.2	3.7
2002	AD-sep	2.1	8.3	4.8	3.6
2003	Untreat	3.3	7.2	3.7	2.4
2003	Sep	1.5	8.6	4.9	3.9
2003	AD	2.8	8.1	4.3	2.9
2003	AD-sep	2.2	8.2	4.2	3.4

Anaerobic digestion and especially separation reduced the dry matter content of the slurry (Table 1). This increases the infiltration rate of the slurry into the soil after application, which reduces volatilisation of ammonia (Sommer & Olesen, 1991) and the potential for odour nuisances following land application of slurry. However, anaerobic digestion of slurry also increases the pH-value of the slurry, which increases the risk of ammonia loss during storage and landspreading of the slurry.
In 2002, the slurry-stores were covered with a 0.15m crust of LECA (lightweight-expanded clay aggregates), which resulted in low nitrogen loss during the storage period for all the tested slurry types (Table 2). In 2003, it was decided not to cover the stores in order to study the effect of covering. The losses of nitrogen from the uncovered stores were considerably higher than from the covered slurry stores, and the highest losses were observed from the treated slurry types (Table 2). The higher loss rate from the treated slurry types was owing to

the fact that anaerobic digestion increases the pH of the slurry and thus the potential for ammonia loss, and that the formation of a natural crust is impeded by preceding separation (Misselbrook *et al.*, 2005). This implies further requirement for preventing ammonia volatilisation from slurry-stores of anaerobically digested and separated slurry by covering the stores with effective crust layers or canvas covers.

Table 2. Monthly relative loss of nitrogen from covered and non-covered stores with the four slurry types indicated as percentage of the initial nitrogen content

Storage period	Treatment	Untreat	AD	Sep	AD-sep
9/1-1/5 2002	+ covering	0.8	0.9	-	- 0.1
20/3-6/5 2003	- covering	2.5	4.4	6.1	4.4

Both anaerobic digestion and separation of the slurry prior to application led to reductions in the ammonia volatilisation during the application of slurry (Figure 1). In 2002 and 2003, respectively, the ammonia loss from applied anaerobic digested slurry made up 83 and 73% of the loss occurring from untreated slurry. Following separation of slurry, ammonia losses will occur both from the liquid fraction and during storage and application of the fibre fraction. In 2002 and 2003, the total ammonia loss from the liquid fraction and from the fibre fraction of separated anaerobic digested slurry made up 98 and 51%, respectively, of the loss occurring from untreated slurry, whereas in 2003, the total ammonia loss from separated slurry made up 40% of the loss occurring from untreated slurry.

Table 3. Concentration of odour (odour units per m^3 of air) in the air above a store with the four slurry types before and after agitation

Treatment	Untreat	AD	AD-sep
Before agitation	200	100	100
After agitation	3000	15000	7000

When the slurry stores were covered by an artificial crust consisting of 15 cm layer of LECA, the odour concentration in air sampled above the slurry was low and close to the detection limit (Table 3). When slurry was stirred prior to application, the artificial crust was degraded temporarily which caused a significant increase in the odour emission (Table 3). The strongest odour emission in connection with agitation was observed from the anaerobic digested slurry types. This may be due to the fact that organic industrial waste was added to the slurry before it was anaerobically digested in order to increase the biogas production (co-digestion). The addition of malodorous substances such as slaughterhouse waste and fish offal may, therefore, increase the risk of odour nuisances during handling of anaerobically digested slurry.

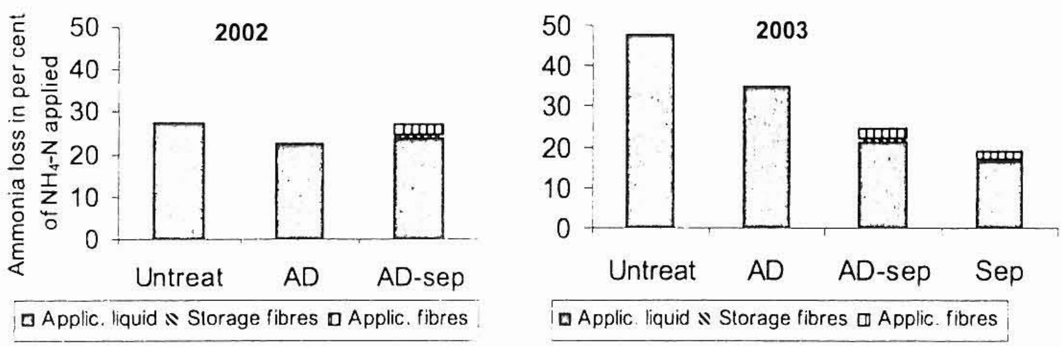

Figure 1. Ammonia volatilisation loss in per cent of applied ammonium for the four slurry types. The ammonia loss was experimental determined during slurry application and during storage of the fibre fraction and estimated for application of the fibre fraction. The studies were performed in the spring of 2002 and 2003, respectively

Treated slurry types have a better ability to infiltrate into the soil because of their lower viscosity. Therefore, lower odour emission rates were seen for slurry types that had previously been treated by anaerobic digestion or anaerobic digestion and separation (Table 4). The higher odour concentrations observed four hours after the application were probably due to the increase in temperatures.

Table 4. Odour concentration (odour units per m^3 of air) in air samples of the four slurry types taken above trailed hose. The air samples were taken 20 and 260 minutes after the slurry application

Min after application	Slurry temp.	Untreat	AD	AD-sep
20	10.7	300	250	150
260	15.6	1000	450	150

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ATTACHMENT NO. 3

PAPER PUBLISHED BY UNIVERSITY OF HOHENHEIM GERMANY

Influence of slurry pretreatments and application techniques on ammonia emissions after landspreading of slurry on grassland.

Influence d'un prétraitement du lisier et des techniques d'épandage sur les émissions d'ammoniac après apport de lisier de porcs sur prairies.

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Abstract

More than half of the German ammonia emissions are caused by the landspreading of slurry. Aftereffects as loss of nitrogen fertilizer and environmental damages should be reduced through suitable processing improvements in slurry management. For recording the influence of different slurry pretreatments and application techniques on the ammonia emissions after landspreading of cattle slurry on grassland a system of three parallel operated windtunnels was used.

Landspreading of separated slurry reduced the ammonia volatilization by 72 % for the liquid phase and by 32 % for the solid phase. The liquid phase with a dry matter content of 3.1 % infiltrated very fast into the soil in contrast to the solid phase. However, the solid phase covered only about 1/3 of the grassland surface because of the higher dry matter content of 16.1 %.

The asumption that following a pretreatement of slurry with certain additives the ammonia emissions after landspreading are reduced, was not verified. The additives "Zeolit", "Biplantol G" and "BVG-mixture" had no effect on the emissions as well as an addition of untreated lime or treated lime "Penac G".

The application of anaerobically fermented slurry even increased the ammonia emissions by 23 % for the mesophil phase and by 47 % for the thermophil phase. The decrease of the dry matter content and it's reducing effect on the volatilization was covered from a very strong increase of the pH value, which caused higher emissions from the digested slurry.

Ammonia emissions could be reduced through application techniques which apply the slurry in narrow bands near or into the soil. In comparison to broadcast spreading with a splash plate, the nitrogen loss was reduced by 40 % using a trailing hose, by approximately 55 % using a trailing foot and even by 75 % using the trenching technique. The disadvantages of an application technique which incorporates the slurry into the soil are a higher draftforce requirement and an increase of *the CO_2 and N_2O emissions. Therefore the most suitable application techniques are the one which apply the slurry near the soil.*

Therefore the application techniques have a very high potential to reduce the ammonia emissions after landspreading of slurry, in contrast to the different pretreatements of the slurry, which can have a reducing effect or none effect or even a rising effect on the ammonia emissions.

Further researches on the influence of climatic conditions such as air temperature, soil humidity, windspeed and radiation are just under investigation.

Keywords : windtunnel, ammonia emission, slurry pretreatments, application techniques.

Résumé

Suite au fait que l'épandage de lisier cause plus de la moitié des émissions d'ammoniac de l'Allemagne et que souvent plus de 50% de l'azote du lisier sont perdus pendant l'épandage, une étude des facteurs qui influencent ces pertes, a été réalisée. Comme stations d'essai, trois tunnels ont été construits, qui permettent de mesurer au champ les émissions d'ammoniac en variant un seul facteur d'influence. La calibration des tunnels avec gaz d'ammoniac aboutit à un taux de recouvrement de 77 à 99% de l'ammoniac. Des investigations sur l'influence de différentes techniques d'épandage de lisier sur les émissions d'ammoniac, ont montré que comparativement à un épandage de surface, l'épandage à l'aide de « tuyaux traînés » diminue de 40% les émissions. Avec un « trailing foot » la diminution est de 55% et avec un soc d'enfouissage en ligne de 75%. Donc, les émissions peuvent être réduites si le lisier est épandu directement sur ou dans le sol. Une séparation du lisier avant l'épandage donne une réduction de 32% si seulement la phase solide est épandue et 72% pour la phase liquide. La phase solide couvre avec 16,1% de MS seulement un tiers de la surface et la phase liquide avec 3,1% MS est rapidement absorbé par le sol. L'utilisation des additifs « Zeolith » et « Biplantol G » n'a aucune influence sur les émissions d'ammoniac, de même que la poudre de chaux non pré-traitée et pré-traitée « Penac G ». Des investigations sur l'influence d'une fermentation aérobie et anaérobie avant l'épandage et sur l'influence des conditions climatiques pendant l'épandage sont à l'étude.

Mots-clés : tunnel, émissions d'ammoniac, techniques d'épandage de lisier, pré-traitement de lisier.

1. Materials and methods

For recording the factors of influence on the ammonia emissions after landspreading of slurry, the Institute of Agricultural Engineering of the University of Hohenheim developed a windtunnel system (Falk, 1994). A parallel operation of three windtunnels allows a specific variation of one influence factor under constant ambient conditions (fig.1).

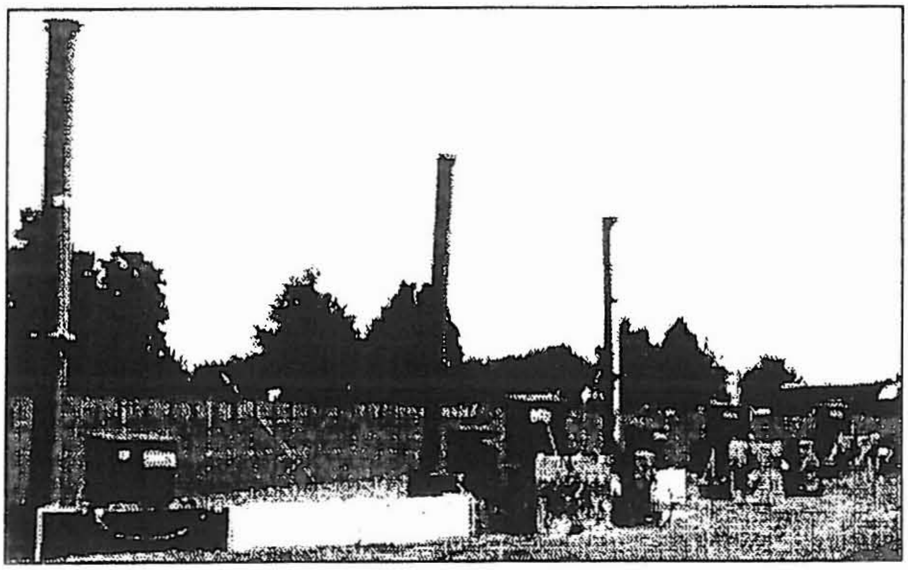


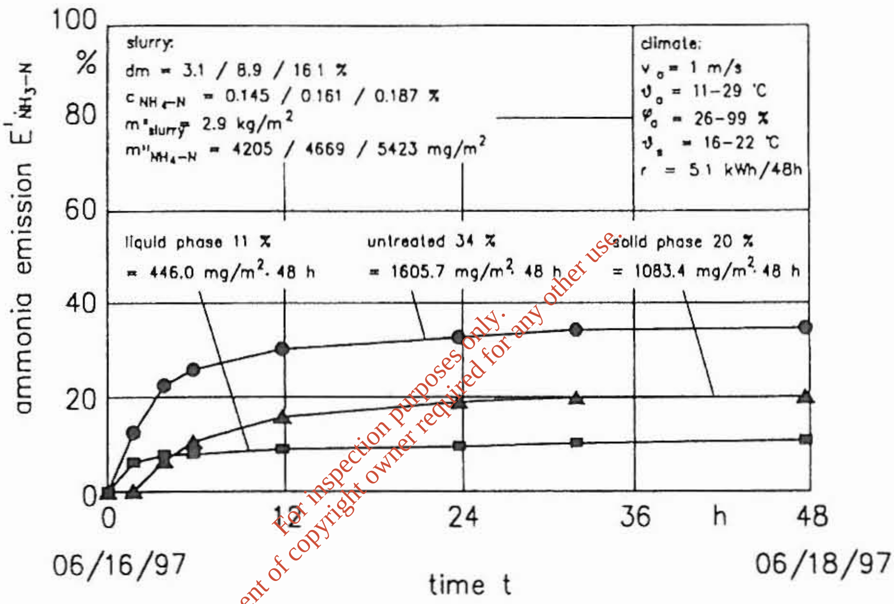
Figure 1
Windtunnel system of Hohenheim

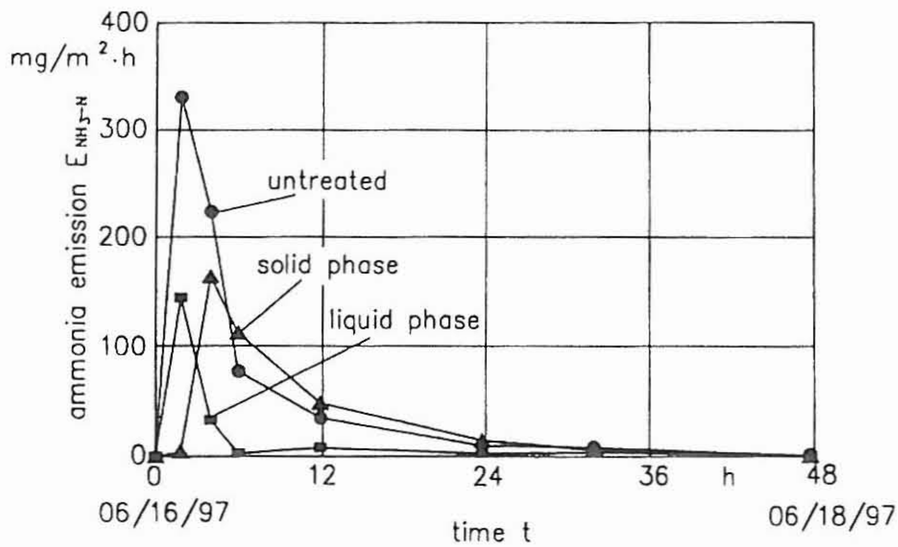
Researches on the accuracy of the windtunnel system gave percentages recovery ranging 77 % to 99 %. A representative sampling could be confirmed by the equality of the different samplers. An equalization of the three windtunnels gave a maximal NH_4-N difference of 200 mg/m² in 48 h (Reitz and Kutzbach, 1997). The accuracy of the Hohenheim windtunnel is similar to the one of other systems (Van der Weerden et al., 1996; Katz, 1996), thus, a reproducible quantification of ammonia emissions is ensured.

2. Results and discussion

So far researches on the influence of different slurry pretreatements and application techniques were carried out. As an example for the pretreatements the influence of a separation on the ammonia emissions is presented. Figure 2 and Figure 3 depict a comparison of an untreated slurry with the solid and liquid phase of a separated slurry. The ammonia emissions are shown in Figure 2 as the cumulative loss of NH_3-N expressed as the percentage loss of applied total ammoniacal nitrogen (TAN) from the slurry. Figure 3 presents the ammonia emission rates expressed in mg/m^2 h.

For the separation a cattle slurry with a dry matter content of 8.9 % and a NH_4-N concentration of 0.161 % was used. After the separation the dry matter content and the NH_4-N concentration of the liquid phase amounted to 3.1 % or 0.145 % respectively. The dry matter content of the solid phase was 16.1 %, the NH_4-N concentration amounted to 0.187 %. The amount of broadcast spread slurry was 2.9 kg/m^2, thus, the amount of ammonium nitrogen applied was 4669 mg/m^2 for the untreated slurry, 4205 mg/m^2 for the liquid phase and 5423 mg/m^2 for the solid phase. The climatic conditions during this research in June 1997 are also shown in Figure 2.





Figures 2 and 3
Influence of separation on ammonia emissions, comparison of a untreated slurry with the solid and liquid phase of a separated slurry

The highest nitrogen loss was found for the untreated slurry. Its total ammonia loss amounted to 1605.7 mg/m² in 48 h, that corresponds to a cumulative loss of 34 % of the TAN applied. By the solid phase emitted 1083.4 mg/m² in 48 h or 20 %. With a total loss of 446.0 mg/m² in 48 h or 11 % the liquid phase showed the lowest emission. The emissions of the untreated slurry were approximately two-fold higher than the ones of the solid phase and even threefold higher than the emissions of the liquid phase. If the emission of the untreated slurry is rated as 100 %, the loss of the solid phase is 68 % and the loss of the liquid phase 28 % of the amount of the untreated slurry. This corresponds to a reduction of the nitrogen loss of 32 % for the solid phase and of 72 % for the liquid phase.

The reduction potential of the separated slurry is explained through the changes in the dry matter content. Due to the lower dry matter content the liquid phase had a lower viscosity and inflitrated better and faster into the soil. Thus, an emitting surface existed only a short time, which is emphazised by the low emission peak of 144 mg/m² h^{-1} already 2 h after landspreading. As opposed to this the solid phase had with 163 mg/m² h^{-1} the highest emission rate 4 h after the application, because only one third of the grassland surface was covered with slurry. The solid phase stucked on the grassland plants because of the higher dry matter content, which explains the following higher emission rate. Caused by the great emitting surface the untreated slurry had with 331 mg/m² h^{-1} as well 2 h after landspreading an emission peak. Afterwards the emission rate of the untreated slurry declined faster than the one of the solid phase, since the slurry was better absorbed from the soil because of its lower dry matter content. For all three slurries approximately 90 % of the total emission occured already after 24 h. At the second day the emission rates were very low and the concentrations were only slightly over the background atmospheric ammonia concentration.

Pain et al. (1990) found corresponding reductions of the nitrogen loss by the liquid and solid phase of a separated pig slurry. Thompson et al. (1990) determined similar ammonia emissions from an unseparated slurry and a liquid phase of a separated slurry, because of a very small difference in the dry matter contents of only 1.5 %. In contrast to this Dosch (1996) found, a decrease of the nitrogen loss by the liquid phase, but an increase by the solid phase. In the sum of liquid and solid phase the ammonia emissions of the separated slurry were still less than the one of the unseparated slurry. Thus, the separation technique is an efficient possibility to reduce the nitrogen loss, provided that the change of the dry matter content is high enough.

A survey of the influence of further pretreatements and application techniques on the ammonia emissions after landspreading of slurry is given in Table 1. There are presented as the cumulative percentage ammonia emissions of different slurry additives, anaerob fermented slurry and slurry applied with different application techniques.

The addition of untreated lime or treated lime "Penac G" had no influence on the reduction of the ammonia emissions. Due to a very low dry matter content of 2.9 % and a very dry soil (soil moisture 14 %) all emissions were very low. Since the differences between the variations were smaller than the measurement deviations of the windtunnel system, no differences between those additives could be obtained. In the same way the ammonia emissions could not be reduced through the additives "Zeolit", "Biplantol" and "BVG-mixture". In oppose to this, Mannheim (1994) found under different conditions a reduction of the ammonia emission by 16 % using "Penac G". Martinez et al. (1997) examined five additives and could only determine a reducing effect for two. Moreover additives mainly influence the homogenization of the slurry and have only a limited effect on the reduction of ammonia emissions (Kunz, 1997).

influence factor	variation and cumulative percentage ammonia emission

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