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AGRICULTURE & INNOVATION

EIP-AGRI Focus Group
Reducing livestock emissions from Cattle farming

Mini-paper – Housing techniques as mitigation options for emissions from cattle barns

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Introduction

Cattle farming, and especially dairy production, is an important source of ammonia and greenhouse gas (GHG) emissions in the EU. At animal housing level, both existing regulations and mitigation options mainly address ammonia.

Overall, mitigation options for cattle are relatively limited compared to pig and poultry production. This can be attributed to the fact that emissions from mechanically ventilated (MV) barns are in general easier to assess and control, compared to those from naturally ventilated (NV) barns which are typical for cattle housing. This technical complexity related to cattle farming is further addressed in the mini-paper on 'measuring and monitoring emissions'.

Furthermore, the scale and layout of NV cattle buildings vary considerably across the EU making it a challenge to provide in widely applicable mitigation techniques. There is also a large diversity in respective regulations and implementations of mitigation techniques throughout the EU. Current implementations are mainly located in North-Western countries like The Netherlands, Flanders (Belgium), Denmark and Germany.

At present there is a selection of mitigation techniques available, especially for dairy cattle. These techniques, at different stages of development and implementation, can be grouped into the following types:

- Floor based systems (including scrapers and cleaning robots);
- Litter based systems;
- Slurry management techniques at pit level;
- Indoor climate control techniques;
- End-of-pipe techniques (air scrubbers).

In practise there is still a big need for further optimisation of these existing systems and for the development of new techniques. It should also be noted that most housing techniques are difficult to implement existing buildings. New developments are most urgently needed for beef cattle. Based on science and the expertise available from mitigating mechanically ventilated barns, several pathways can be identified to further optimize existing and develop new mitigation techniques. With this respect, emission reduction techniques at animal housing level should aim to affect one or more of the following important key factors and/or driving forces of the ammonia emission process:

- TAN source strength (see mini-paper on feeding strategies);
- Draining capacity of the floor for direct transportation of urine to the manure storage;

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- Residence time of open urine/manure sources;
- Emitting surface area of open urine/manure sources;
- Urease activity in urine puddles;
- Urine/manure pH and temperature;
- Indoor air temperature;
- Air velocities at the level of critical emitting surfaces (e.g. urine puddles at floor level and slurry surface in the pit);
- Air exchange between the slurry pit headspace and the indoor air;
- Exhaust of indoor air.

The aim of this mini-paper is to describe the main characteristics of the different types of existing and promising emission reduction techniques at housing level, including their respective technical challenges and needs. This overview is then illustrated by some working examples from practise. Furthermore, this mini-paper focuses on the needs and perspectives for respectively farmers, constructors and regulators. Finally, some proposals for actions are presented.

Main characteristics of existing and promising techniques

Floor based systems

Both slatted and closed floor systems for dairy cattle are adapted to e.g. enhance urine runoff, provide in separation of urine and faeces or limit air exchange with the pit. These adaptations mainly concern different profiling patterns in the floor creating build-in urine channels. Next to concrete, also plastic materials can be applied to provide in smoother surfaces or draining systems with retractable valves that limit air exchange.
These floor systems are generally equipped with different types of manure scrapers or cleaning robots. Also spraying systems can be installed to dilute and remove urine puddles and allow better manure scraping that enhance urine draining. Spraying systems can be combined with the use of urease-inhibitors to reduce urea conversion on the floor.

Technical challenges and needs:

- Draining systems in closed floors designed for low emission tend to clog with manure which can result in higher emissions compared to traditional systems.
- Scraper/cleaning robot efficiency is generally poor (insufficient floor contact can cause smearing of manure, frequent mechanical breakdown, effect of scraper frequency is poorly known,…), insufficient scraper efficiency negatively affects the drainage capacity leaving high amounts of urine on the floor. Integrated designs of floor layout and scraper are in need here.
- Spraying efficiency is poorly known and very dependent on spraying pattern, frequency,…
- Performance & reduction efficiency in practise does not meet results obtained under more standardized conditions.
- Air exchange between head space of manure storage and barn air is known as potential strong driver of emission. Its quantification and control is technical challenge to be solved.

Litter based systems

Litter based systems are generally used for beef cattle and typically consist of straw material. Mechanical pre-treatment (e.g. pelletizing, chipping) and/or the use of alternative organic resources (e.g. woody material, flax) could provide in ammonia emission reduction through e.g. lowering pH, enhancing bacterial activity, higher absorption. The availability of practical options is very limited until present.

Technical challenges and needs:

- Performance & reduction efficiency largely unknown;
- Availability and costs of alternative organic sources can be very variable and uncertain.

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Slurry management techniques at pit level

Several techniques can be applied at slurry pit level to limit the ammonia emission process. Additives may affect e.g. slurry pH (acidification), urease activity (inhibitors) and nitrification processes. Low rate intermittent slurry aeration could induce chemical reactions (e.g. oxidation) or biological activity. Effects on manure properties (e.g. pH) are largely unknown. It can however 'break' the slurry crust prohibiting 'secondary' puddle formation at slurry pit level, thus reducing emissions.
It is evident that removal of slurry from the barn will result in emission reduction. Slurry removal from the pit can be realized by e.g. a pumping or scraper system. The removed slurry should be stored in closed facilities or could be further processed at the farm (e.g. anaerobic digestion). The latter can generate an added value for the farmer (e.g. energy production).

Technical challenges and needs:

- In many cases, additives are of unknown composition which makes it difficult to identify emission reduction mechanisms.
- Except for acidification, performance & reduction efficiency are largely unknown.
- Considerations to be made at production chain level (e.g. manure application).

Indoor climate control techniques

Lowering indoor temperature and air velocities near emitting surfaces can reduce ammonia emission. This can be achieved by smart application of ACNV (Automatically Controlled Natural Ventilation). Also roof insulation is expected to provide a positive effect.
Indoor air treatment techniques like e.g. fogging can provide in reduced emissions.

Technical challenges and needs:

- The emission reduction potential of these techniques is not yet quantified.
- ACNV is used in practise but current controlling algorithms are not aimed to reduce emissions. Furthermore, it is not yet known how ACNV should be performed with this respect and what the potential effect would be on the ammonia emissions. With this respect it is also still a challenge to determine 'regular' ventilation management.
- When applying ACNV to reduce emissions care must be taken to avoid heat stress.
- Fogging could also enhance NH_3 emissions from solid manure due to increased moisture.

End-of-pipe techniques

End-of-pipe techniques generally have a high removal efficiency for ammonia and are widely used in pig and (to a lesser extent) poultry production. Implementation of these systems in cattle barns necessitate more closed (hybrid) ventilation systems in order to maximize the ratio treated/untreated air. Alternatively, a more source-based approach lies in air extraction from the pit headspace. Air treatment can be obtained by both chemical, biological or mixed scrubber systems.

Technical challenges and needs:

- Still development needed of smart (hybrid) ventilation control system e.g. based on pressure difference measurements to control and assess the 'by-pass air'.
- Effects on profitability and productivity should be investigated.
- Seems difficult to implement in 'warm countries' with very open houses.

Technique combinations

Most individual techniques, except for end-of-pipe techniques, have an emission reduction efficiency in the range of 15-30%. Combining different techniques allows to achieve higher reduction efficiencies, e.g. combining feeding strategies, floor cleaning, smart ventilation,…

Conclusions and general remarks

It can be concluded that for most types of techniques there is still an urgent need for optimization and innovation. This applies especially for beef cattle where only a limited amount of techniques are currently available. Respective technical challenges and needs are identified.

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Overall there is a strong need for reliable and unbiased information concerning technique performances and related management and costs. These knowledge gaps also imply the urgent need for standardized and validated tools for 'technology assessment'.

Information and working examples from practice

In The Netherlands and Flanders (Belgium) there is information available on allowed management and housing techniques for ammonia emission reduction. These also include technique combinations and techniques applicable to cattle barns, which are mainly floor based.
http://www.infomil.nl/onderwerpen/landbouw-tuinbouw/ammoniak/rav/stalbeschrijvingen/map-staltypen/hoofdcategorie/ (in Dutch)
https://www.vlm.be/nl/themas/Mestbank/mest/emissie/Lijst-van-emissiereducerende-maatregelen-in-het-kader-van-PAS/pas-lijst/Paginas/default.aspx (in Dutch)

Although being at different stages of development and implementation, there are several working examples of promising emission reduction techniques available. These are mainly located in The Netherlands and Denmark. Some examples are:
http://www.dairypower.com/slurry-aeration/ (low rate slurry aeration)
http://www.conferencemanager.dk/acidification (slurry acidification)
http://agrifarm.dk/en/technologies/air-cleaning-in-the-dairy-barn (manure pit air extraction)
http://edepot.wur.nl/358259 (air scrubber, in Dutch)
http://www.winstal.nl/specialismen/luchtwasser/ (air scrubber, in Dutch)

Much can be learned from through cross fertilisation from livestock other than cattle. Also the concept of technique combinations is to be further explored.
http://agrifarm.dk/en/the-first-hybridventilated-farm)

Needs and perspectives for farmers, constructors and policy makers

From a farmer's perspective, implementing emission reduction techniques at housing level generally poses big challenges in terms of investments and management. The farmer is often confronted with regulatory obligations to invest in techniques that are personally regarded to be 'non-productive' and generally 'a burden' with regard to his day-to-day management. Moreover, implementing these techniques could pose a threat to the farmer's overall cost-effectiveness, which is currently already being stretched. In technical terms it is important that developed low emission systems do not conflict with other management requirements. For example, the implementation of 'closed' low emission floors in practice was strongly slowed down by locomotion problems of the animals due to slippery surfaces.

Livestock producers are looking ahead 20-30 years when planning investments on livestock housing. In order to get efficient and effective mitigation techniques in place, it is vital to get interaction between farmers, constructors and policy makers to boost technology innovation. Especially with regard to mitigation techniques it is of the greatest essence to provide in a framework that allows to develop a joint long term vision and action plan for farmers, suppliers and policy makers. It is strongly advisable to establish this both at EU and member state level.

Initiatives should be put in place to turn around the farmers' feeling of 'burden' into benefits for the farmer. This could be established through:

- Easy access to a wide range of available emission reduction techniques at housing level, including adapted techniques for existing barns;
- Reliable and unbiased information with regard to performance, production, management and costs related to the respective techniques;
- Raising awareness of benefits related to production, animal health, better work space, societal acceptance,…;
- Financial incentives;

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- Introducing the concept of 'license to produce', possibly including monitoring systems at housing level (cf. paper on measuring techniques);
- Raising cost-effectiveness of mitigation techniques through e.g. extra valorisation of removed manure (e.g. bio-digestion).

Constructors should be stimulated to direct their R&D strategies (both short and long term) towards the farmers' needs and also in view of policy perspectives. To allow the constructors to play their vital role in technology innovation, there is need for:

- Clear regulatory framework, preferably at EU level;
- Monitoring of building developments throughout the EU;
- Efficient, cost-effective and transparent 'technology assessment' methodologies, preferably identical throughout the EU (mutual acceptance of respective member state assessments, reference to VERA **www.vera-verification.eu**);
- Availability of cost-efficient assessment techniques (including scientific evaluation of emission reduction working principles, measuring at different scales, modelling,…);
- Availability of innovation support (know how centres & funding facilities);
- Low access to know how centres for support in technology development, including knowledge transfer to the construction chain.

In order to develop an effective and consistent regulatory framework, policy makers need knowledge input concerning:

- Potentially effective techniques including identification of most promising techniques that need further optimization/development;
- Possible pathways to optimize/develop selected techniques (including co-operations, funding, stakeholders,…);
- Adapted 'technology assessment' tools and testing facilities;
- Evaluation of performed 'technology assessments';
- International bench marking.

Proposals for actions

The following priorities for potential innovative actions are proposed to stimulate the knowledge, to test solutions and to multiply positive effects within the agricultural sector:

- Stimulate the development of adapted mitigation techniques with priority for improving scraper efficiency (floor based systems) and ACNV (indoor climate control);
- Stimulate the development of adapted tools for Technology Assessment;
- Stimulate the availability of infrastructure to perform Technology Assessments;
- Development of databases with all relevant information on mitigation techniques;
- Subsidize demonstration actions of innovative mitigation techniques (both proven and promising techniques);
- Organize stakeholder co-operation at both EU and member state level.

So future research work should focus on development of adapted mitigation techniques and tools for technology assessment, as mentioned. To become a success story it is vital that local agricultural and innovation systems are sufficiently equipped to discuss adaptation strategies with farmers. In some countries like Belgium (Flanders, **www.VEMIS.be**), The Netherlands, Denmark,… there is a close co-operation between knowledge centres, policy makers, advisory services, suppliers, farmers organisations,… This can be further induced throughout the EU through local initiatives like EIP operational groups. The latter can also include demonstration actions.

There is a clear link with Cost Action CA16106 (starting in 2017) on Ammonia and Greenhouse Gases Emissions from Animal Production Buildings (Acronym: LivAGE).

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