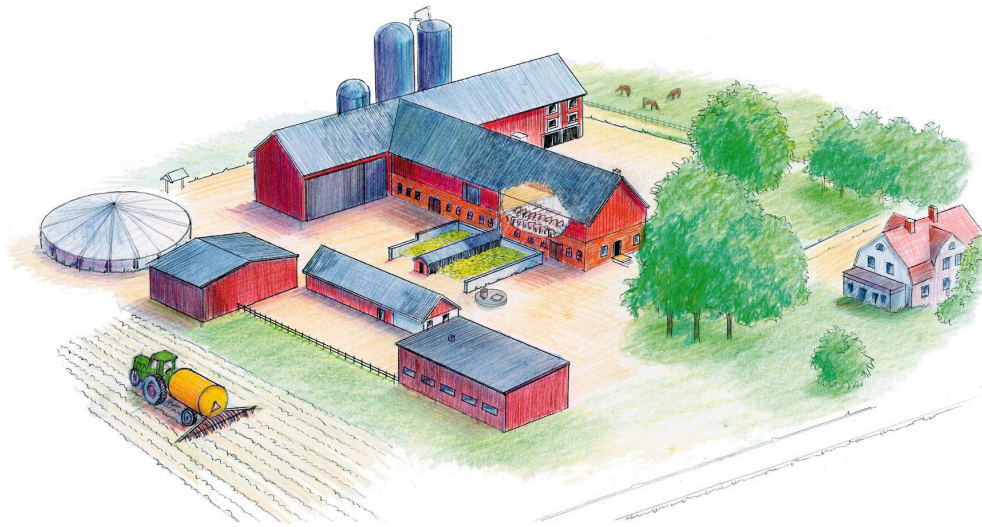




# **LIFE Ammonia**

## **Towards a sustainable milk production**

– reducing on-farm ammonia losses



Information from a project at the Swedish University of Agricultural Sciences, Skara, Sweden

# LIFE Ammonia

## Towards a sustainable milk production

– reducing on-farm losses

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Ammonia is a highly reactive gas that has important effects on the atmosphere chemistry and sensitive terrestrial and aquatic ecosystems. Ammonia deposition affects the environment through eutrophication and acidification of ground and water. Agriculture is the major source of ammonia emission to the atmosphere, mainly from manure excreted by livestock. Ammonia deposition is an international problem and there are strong pressures within EU to lower ammonia emissions from agriculture. In Sweden one of the Environmental Quality Objectives is that the ammonia emission should be reduced by 15% from the level of 1995 to 51,700 tons in 2010.

### The aim of the project

The project **Life Ammonia** aimed to demonstrate and evaluate an efficient and innovative combination of techniques and methods for the reduction of on-farm ammonia losses in milk production, without any substantial negative impact on animal health, plant production, environmental hygiene or quality of end products, and to increase the knowledge in this area among Swedish and European farmers, extension workers, authorities and agricultural students. Following main areas for reduction of ammonia emission were identified:

- Adjust the protein level in the feed and improve the nitrogen efficiency.
- Use best known techniques for stalling, ventilation and manure handling.
- Change to slurry handling system with storage in a covered tank.
- Use best known technique for spreading slurry.

The old barn at the research farm Brogården at the Swedish University of Agricultural Sciences in Skara was used for the project. The project started in November 1999 and finished in October 2003.

### The research farm

The 42 cows at Brogården were housed in a stanchion barn, equipped with long-stalls for tied cows. The average production was 10,100 kg ECM (energy corrected milk). In the summer of 2000 the old fittings, manure-handling system, gutters and floors were removed and new tie-stalls and equipment for milking, ventilation and manure handling were installed. A new mixing pit for slurry and a manure store with canvas roof covering was built. The conditions on the farm were monitored before and after rebuilding.

Special efforts were made to design the stalls, manure removal system and ventilation system in such a way to minimize ammonia emission. The manure gutters had efficient urine separation and urine channels equipped with an auger for mechanical cleaning. Plastic pipes for incoming water were placed just beneath the surface of the concrete in the bottom of the gutters, in order to cool the surface and reduce the ammonia emission. The temperature of the drinking water was increased by 5-6 °C. The gutters were cleaned by a hydraulic scraper system. Urine and faeces were transported out of the building separately and then mixed in an outdoor pit. The rearmost 32 cm of the tie-stalls consisted of aluminium profiles with rubber covering, so called rubber slats, which kept the stalls clean and dry. See figure 1.



**Figure 1. New tie-stalls equipped with rubber slats.**

A new ventilation system was installed, new channels for incoming air were built and all fans were fitted in a separate room outside the main building. The exhaust air was pressed via a channel through a biofilter consisting of shredded wood and straw prepared with ammonia binding bacteria. See figure 2



**Figure 2. Biofilter**

The new stalling, ventilation and manure handling systems improved the environment inside the barn considerably; the ammonia concentration in the air was reduced from 8-10 to 2-3 ppm. When the exhaust air passed through the biofilter, nearly all remaining ammonia in the air was absorbed, partly by the irrigation water and partly by the microbes in the filter. The air after the filter contained virtually no ammonia at all. The total emission from the barn was

reduced from 7.2 to 1.0 kg ammonia nitrogen per cow and year, a reduction with 86 %. The rubber slats also improved the cows' claw health and the cleanliness of cows, resulting in healthier cows and a higher milk quality.

## Feeding

The most efficient way to improve the nitrogen efficiency in milk production (the amount of nitrogen in milk as 5 of nitrogen in the diet) is to optimise the protein in the feed ration in respect of protein concentration and protein quality. No changes were made during the winter period before the rebuilding of the barn but during the first two winter periods after the rebuilding the protein level was lowered, on average for lactating cows by 10 gram per kg DM (dry matter). The balance between rumen degradable and rumen undegradable protein was also adjusted. This was achieved by adjusting the cereal part of the feed ratio and by giving dry sugar beet pulp to high lactating cows. During the third winter period after the rebuilding the beet pulp was replaced by a wholecrop barley silage. The milk production dropped somewhat during the first winter period after the rebuilding, caused by the moving of cows to a loose-housing barn during the rebuilding in the summer 2000. During the following periods the milk production increased and was on average 10,300 ECM per 12 month, during the last winter period, 2002-03.



**Figure 3. Feed alley with dividers for accurate feeding**

The changes of the feeding regime improved the nitrogen efficiency from 25 to 27%, calculated for all cows (including dry cows), during the winter period. In the same time both milk production and feed consumption increased so the total amount of nitrogen, in the manure, behind the cows increased.

## Storage of manure

Before rebuilding the manure was stored as farm-yard manure on a concrete pad and the urine was stored in a pit, covered with Leca pebbles. The ammonia losses were measured to be 6.5% from the farm-yard storage and 5.0% from the urine pit. After rebuilding of the barn the

slurry was stored in a round concrete container equipped with a canvas roof. See figure 4. The losses from the covered store were less than 1%.



**Figure 4. Slurry store with canvas roof.**

The change to slurry handling reduced ammonia evaporation during the storage period with 95%, from 4.1 to 0.2 kg ammonia nitrogen per cow and year.

### **Spreading of manure**

Before rebuilding the farm-yard manure was spread with a traditional broadcasting manure spreader and the urine was spread with a spreader equipped with trailing hoses, see figure 5. In total 10.4 kg ammonia nitrogen per cow and year were lost with this technique. During the years after the rebuilding the slurry was mainly spread with the same band spreader as for urine. The slurry was spread during springtime in growing crops. The emission was recorded to be 6.1 kg ammonia nitrogen per cow and year, corresponding to about 11% losses of the nitrogen available to plants.

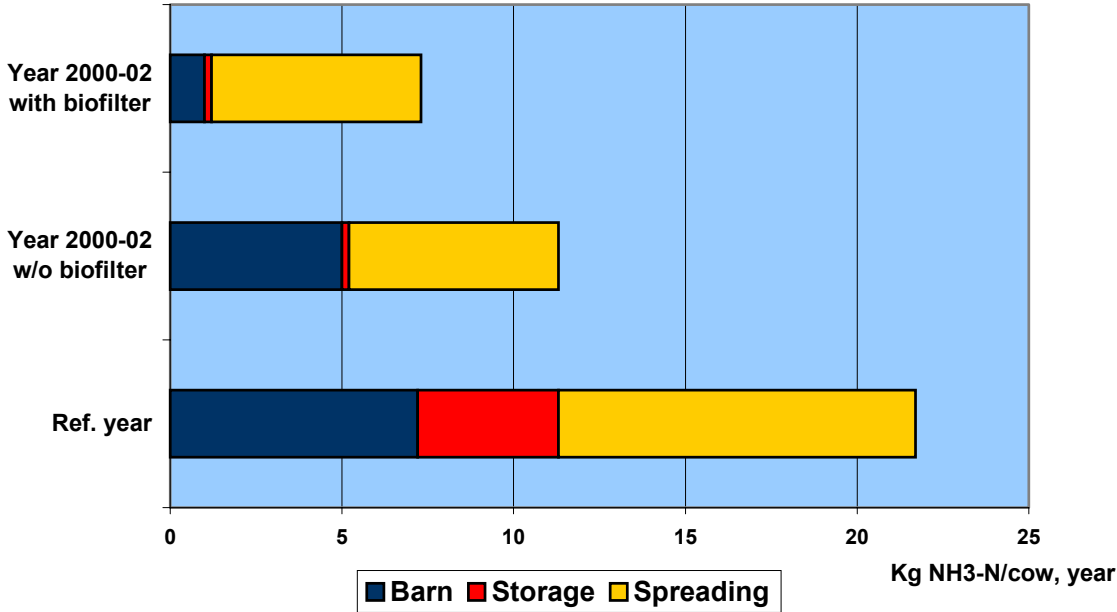


**Figure 5. Slurry spreader equipped with trailing hoses.**

With the new slurry system the losses at spreading were reduced from 10.4 to 6.1 kg ammonia nitrogen per cow and year.

**Total reduction of ammonia emission.**

During the first two years after the rebuilding, 2000-01 and 2001-02, the ammonia evaporation from the research farm was reduced with 630 kg ammonia nitrogen, compared with the reference year, corresponding to a reduction of almost 70 %. Excluding the effect of the biofilter the reduction was 420 kg ammonia nitrogen, corresponding to a 45 % reduction. Picture 5 shows the differences calculated per cow and year; a reduction from 22 kg during the reference period to 7 kg ammonia nitrogen including the biofilter (12 kg excluding the biofilter). The ammonia losses per kg milk produced was reduced from 2.3 g to 0.7 g.



**Figure 5. Ammonia emission from Brogårdén prior to and after rebuilding.**

The nitrogen flow at farm level improved during the project period. In the year 1999-2000 the surplus of nitrogen was 106 kg per ha, which decreased to 74 kg per ha, on average, during the two years after rebuilding. The nitrogen efficiency increased during the three years from 48 to 56%.

**Cost-benefits**

The cost analysis of the actions taken on the project farm indicated that the transfer to slurry system was the most cost efficient measurement. The slurry handling system gave several advantages; less work, a better utilisation of nitrogen and a more even distribution of manure on the field. Less mineral fertilizer had to be bought in.

The increased nitrogen efficiency in milk production, (by about 2 percent points), did not give any immediate cost reduction at Brogårdén, as special concentrates was mixed for the project. The effect of the improved conditions inside the barn could not be directly seen, but improved hoof health, cleaner cows and lower ammonia concentrations in the air probably influenced the milk revenues positively.

## **Dissemination of project achievements**

At an early stage the website [www.ammoniak.nu](http://www.ammoniak.nu) was established, containing background information, project description and actual progress reports from the project. The newly rebuilt cowshed had some 1600 visitors, farmers, students, advisers and others, during the project period. The project Manager and project members held several lectures at meetings with farmers and advisers. Several presentations were made at conferences and seminars in Sweden, Denmark and Italy. A special seminar was held in Skara in Sep. 2003, at the end of the project period, summarizing all results. Agriculture magazines had several articles about the results from the project and a separate leaflet presenting the result after the first two years was published.

One major output from the project was the “Practical Advices”, containing 8 different recommendations for reduction of ammonia emission from dairy farms, and distributed to about 19,000 farmers, advisers and other actors within the milk sector in Sweden.

## **Applicability of project results**

The main objectives in the project were fulfilled and the farm could demonstrate a number of techniques to reduce the ammonia emission from a traditional dairy farm. The feeding strategy used in the project can be adopted easily by any dairy farmer, with tied cows or loose housing. Most likely the nitrogen efficiency in milk production in Sweden is closer to 25% than 30%. Calculations made, (Gustafsson, A. H., Swedish University of Agricultural Sciences, pers. comm., 2003) has indicated that by a 2 percent points improvement of nitrogen efficiency in milk production, the total ammonia losses from dairy farms in Sweden would be reduced by 500–1700 tons of ammonium nitrogen per year, which would correspond to 7–23% of the total target of 7,300 ton per year. Milk production with less protein in the diet is often discussed and the general recommendations will most likely be adjusted in Sweden.

The change in housing system reduced the ammonia losses inside the cowshed with about 20%. The bio-filter outside the barn absorbed most of the ammonia in the outgoing air. It would however not be feasible for all farmers to use such a filter. New cowsheds are mainly built as loose-housing systems, most of them having natural ventilation without mechanical fans. The bio-filter can be recommended in special cases when highly contaminated air needs to be cleaned. Some of the basic knowledge about ammonia evaporation has, however, already been used when designing new systems for manure handling and urine separation.

The main part of the ammonia reduction at Brogården was from storage and spreading of manure, and if 25-50% of the result could be achieved when implementing these techniques on all dairy farms in Sweden the result would mean a reduction of 1000-2000 tons of ammonium nitrogen released to the atmosphere.

### **Funding**

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