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# Manure flushing

## Operation of a manure flushing system in feeding pig production for the reduction of ammonia and odour emissions

*Feeding pig housing represent an outstanding source of ammonia and also odour emissions. Additionally, air quality in artificially ventilated livestock housing through heightened ammonia concentrations means substantial deficits for stockman and animal. Through using flushing gutters under slatted flooring and flushing the manure with a mechanically and also partly biologically treated flushing liquid, ammonia emissions could be reduced by up to 45% and the odour emissions by from around 25 to 71%. The recovery process was used for biological treatment of the flushing liquid, and a batch system was used and evaluated with regard to costs and emissions.*

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**Keywords**

Fattening pigs, ammonia emissions, flushing gutters

Reduction of barn-sourced ammonia and odour emissions with this system took place mainly through a decrease in the length of time manure remained in the livestock housing and also a reduction in the surface area of the odour-emitting material. For this research a compartment of a feeding pig house with 120 animals was fitted with a flushing gutter system from Wolters-Agrotechniek (Zwolle/NL) and another compartment without flushing system was used for comparison. The flushing gutters were flushed once daily with fluid which had been mechanical and also partly aerobically-biologically processed.

The biological treatment was applied for an extensive as possible degradation of odour material and for the transformation of ammonia nitrogen to nitrate (nitrification) thus giving a low-emission flushing liquid. In the first trial section the continuous recovery system was used for biological treatment of flushing liquid, in the second a comparable batch system was used.

### Preparation of flushing liquid

The flushed slurry was collected in a preliminary pit and subsequently treated in a two-stage process *(fig. 1)*: In the first stage the flushing liquid was separated through flocculation and sedimentation into a thick sediment and a thin fraction. Through the flocculation even particles with very low sinking rate that would normally have been run-off during sedimentation, could be separated

In the second step approximately 60% part of the sedimentation run-off was aerobically-biologically treated. The remaining 40% was directly run back into the flushing liquid reservoir and there mixed with the run-off out of the bioreactor. This mixture was then used for flushing the pighouse gutters. A repeat rinse with wash or well water was not necessary.

### Housing system and the measuring technique

Exhaust air emissions and internal atmosphere data were recorded from a strawless feeding pig house with large pens for in each case 30 pigs and wet feed tube automatic feeders *(fig. 2)*. Fresh air was introduced through the middle passageway underfloor and exhausted also underfloor in the livestock living areas. The relevant measurements for evaluating emission reductions were conducted at the same time in a neighbouring compartment of the same design but without flushing gutter (reference compartment).

### Results

*Flocculating and sedimentation*

The non-ionic polyacrylamide NF 104 from

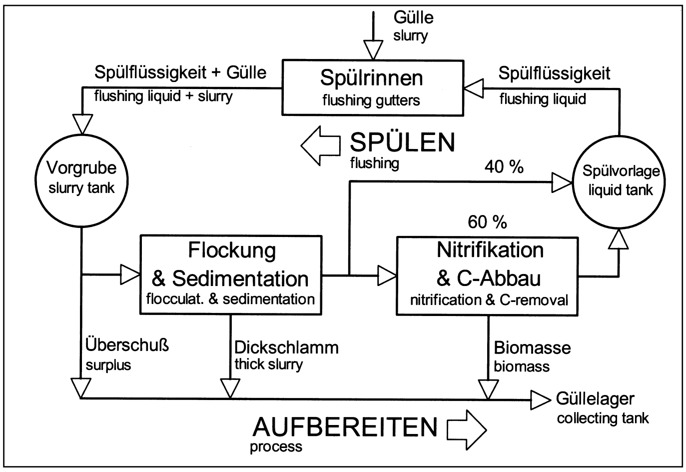


*Fig. 1: Flow chart of the manure flushing system*

BASF dosed at the rate of 8 g per $m^3$ slurry was used for flocculating the flushed slurry in the entry channel to the sedimentation pit. The carbon and phosphate fractions were reduced by half and those of nitrogen by around a third *(table 1)* by sedimentation. This action reduced the load on the biological treatment plant and the costs for ventilation could also be reduced.

*Nitrification and denitrification*

Continual running of the reactor meant the degree of ammonium nitrogen degradation was constantly over 97% up to an area loading of 150 g N per $m^3$ and day. With batch running, the reactor was operated in an area loading range from 50 to 130 g N per $m^3$ and day whereby the degradation degree was also over 97%. This showed the nitrification took place completely with both systems.

Denitrification took place over two hours. Around 75% of the produced nitrite and nitrate mass flow was denitrified in the flushing liquid reservoir by both systems. The process was uncontrolled in that, with the exception of the flushing action, no agitation of the liquid in the flushing reservoir took place. Additionally, the adding of easily-degraded carbon (required as energy source) was unregulated and depended only on the mix ratio used for the biologically treated and untreated fractions. The remaining nitrite and nitrate was denitrified in the holding pit.

*Emissions in the housing exhaust air*

The reduction of ammonia emissions in the livestock house vicinity with continuous and batch operation of the bioreactor was almost identical at 45.1 and 44.7% respectively *(table 2)*. Odour emissions in the range of 8 to 27 odour units per second and adult animal unit (AU) were measured from the flushing gutter compartment. The reduction of odour emissions compared with the reference compartment was between 21 and 75% according to spot check measurements.

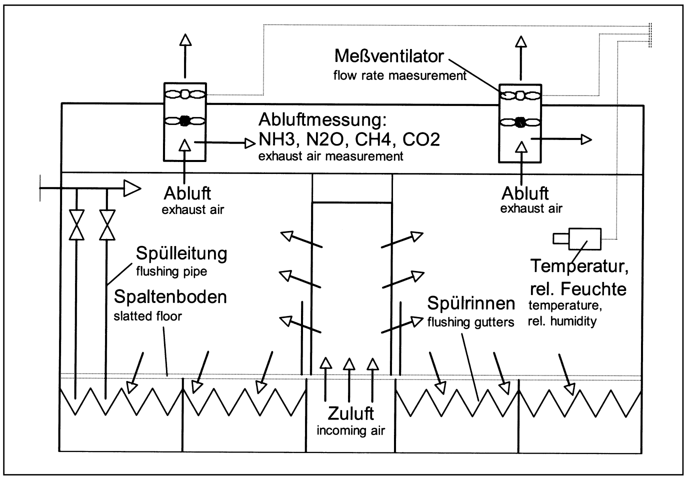


*Fig. 2: Stable system and measuring technology*

*Bioreactor emissions*

As one can see in *table 2*, the ammonia emissions with both continuous and batch systems and full nitrification (> 97%) were in effect zero.

The level of nitrous oxide concentration and the emissions were almost twice as high with the batch system compared with continuous running. A possible explanation for this was that the reactor cycle with batch running included an anoxic phase (sedimentation of the biomass). During this period there was oxygen limitation during nitrification which resulted in nitrous oxide (among other gases) being released as an intermediate product of metabolism and being accumulated in the liquid [2]. The accumulated nitrous oxide was then suddenly released through the renewed and simultaneous activation of the ventilation and reactor agitator. This extreme exhaust gas release with concentration peaks of up to 1000 mg/$m^3$ lasted for up to two hours.

### Summary

The biological process is, in total, more stable with the batch system because the biomass is retained directly in the reactor. Problems of floating material caused by denitrification in the subsequent settling pit were experienced with the continuous system.

Through simultaneous reduction of investment costs by around DM 14 per animal place and a reduction of energy costs of around DM 2 per animal place and year based on a building for 1000 feeding pigs, the batch system appear the better alternative when compared with the continuous system.

## Literature

[1] *Van Gastel, J. und C. Van der Kaa*: Design of biological nitrogen removal systems for pig slurry. Proefstation voor de Varkenshouderij, Proefverslag 1.192 (1997), Rosmalen

[2] *Beline, F., J. Martinez, D. Chadwick, F. Guiziou und C.-M. Coste*: Factors affecting nitrogen transformations and related nitrous oxide emissions from aerobically treated piggery slurry. J. Agric. Engng. Res. 73 (1999), pp. 235-243

| Flocculation substance Dosage | TM [%] | $C_{ges}$ [%] | $N_{ges}$ [%] | P [%] |
|---|---|---|---|---|
| (8gPA/$m^3$ slurry) | 50 | 47 - 58 | 27 - 46 | 55 |

PA: polyacrylamide TM: dry matter ges: total

*Table 1: Removal rates by flocculation and sedimentation*

| $NH_3$-emissions in livestock | $NH_3$-emissions in livestock housing air*1 [g$NH_3$/(TP day)] | $NH_3$-Emissions Flushing gutter*1 [g$NH_3$/(TP day)] | Relative reduction [%] |
|---|---|---|---|
| Continuous running | 11.06 | 6.08 | 45.1 |
| Batch-running | 9.72 | 5.37 | 44.7 |
| **Emissions of the bioreactor** | **Ammoniak** [mg$NH_3$/($m^2$h)] | **Nitrous oxide** [mg$N_2O$/($m^2$h)] | **Methane** [mg$CH_4$/($m^2$h)] |
| Continuous running | 1.9 | 75.5 | 49.8 |
| Batch-running | 0 | 138.1 | 77.4 |

TP: animal place *1: Average over a single feeding cycle

*Table 2: Emissions in the exhaust air of the stable and in the exhaust air of the bioreactor*