TEKNOLOGISK INSTITUT

Test report summary

VERIFICATION OF ENVIRONMENTAL TECHNOLOGIES FOR AGRICULTURAL PRODUCTION

Technology: JH BioAcidification NH4+

Manufactured by: JH Agro A/S

has been tested on one dairy farm according to the VERA test protocol for Livestock Housing and Management Systems (Version 2, 2011-29-08).

The following main results have been documented through the test:

Environmental efficiency:

Ammonia emission reduction efficiency at 34 % when applied to a dairy farm

Operational stability:

The JH BioAcidification NH4+ system has demonstrated a satisfactory operational stability.

Applicant Data

Technology type	JH BioAcidification NH4+ system applied for dairy farms for acidification of cow slurry with an organic acid or a pre-fermented carbon rich biomass to pH below 5.5.
Applied for	Reduction of ammonia emissions from cow housing systems
Technology name	JH BioAcidification NH4+
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Technology Description

JH Agro A/S has developed an environmental technology with the name JH BioAcidification NH4+. The current JH BioAcidification NH4+ system has been developed for reduction of ammonia at cow farms with circular pit systems.

The theory of JH BioAcidification NH4+ system is to acidify manure with an organic acid or a pre-fermented carbon rich biomass, such as molasses, to acidify and to stimulate naturally occurring fermentation of the manure in the pits, resulting in a decline of pH in comparison to acidification with an inorganic acid, bio-acidification uses an acidifying source that can both be consumed and produced in the manure pit. This process is very dependent on the temperature. Bio-acidification has the advantage that all acid produced is biodegradable hence higher biogas potential and reduced sulfate leaching.

Bio-acid is defined as fermented biomass that can be stored safely until it is added to the manure. Bio-acid can for example be molasses that have spontaneous been fermented by naturally occurring

microorganism, which brings the pH down to around 4 and thereby stabilizing the product. Therefore, bio-acid contain both a high density for fermenting bacteria, organic acids from fermentation and a carbon rich biomass that are relatively easy degradable.
Organic acid such as acetic acid can be used to start up the JH BioAcidification NH4+ system. This can be an advantage because development of foam can be controlled with slow addition of an organic acid. If an easy degradable carbon rich biomass is added when starting up a new system, uncontrollable foaming can occur. Startup with bio-acids is safest in spring with gradually increasing temperatures and with as little manure in the pits as possible. The possibility of adding an organic acid is not obligatory for the technology but practical in startup and also as a safety mechanism if bio-acid addition is insufficient.

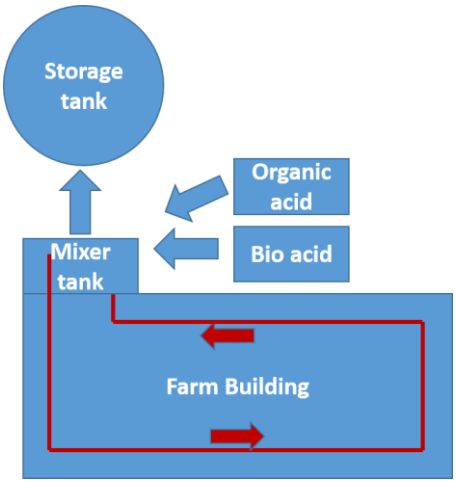

Figure 1 shows schematic overview of the JH BioAcidification NH4+ system.

The manure acidification system for dairy farms includes the following key elements:

- Tanks with bio-acid and optionally organic acid, from where the bio-acid or organic acid is added.
- Mixing tank/pumping well where agitation, acid addition and pumping take place. The mixing tank is generally an existing tank.
- Fresh manure is mixed with bio-acidified manure and returned to the barn in the circular pit below the slatted floor.
- Storage tank, where acidified manure is stored after surplus manure is pumped from the mixing tank.
- Parameters such as pH, temperature and amount of bio-acid added, is being logged in a control unit used for controlling the process.

The JH BioAcidification NH4+ system is operated as follows:

At a present time, every day of the year acidification takes place in the following chronological order:

1. The two pH electrodes which are placed in the mixer tank are flushed with air.

2. Stirring of the manure in the mixing tank begins and manure from the mixing tank is propelled into the circular pit in the barn and recycled to the mixing tank. pH is measured after approximately 10 minutes of stirring.

3. After 10-20 minutes of stirring, a bio-acid is added from the acid tank to the manure in the mixing tank. A cavity pump is used for this purpose. Bio-acid is added directly into the mixing tank at a programmed time. The addition time, which equals the acid amount, is calculated from the pH drop and the added bio-acid the provirus day/days.

4. The stirring stops, when all manure is acidified (depends of pit length and pump capacity normally after 30-60 minutes of stirring). Just before the stirring stops, pH is measured and the value stored.

5. The process is repeated the day after and pH is again measured in the mixing tank. The amount of bio-acid added is calculated on the basis of the previous added amount and the effect on pH. If the pH threshold (maximum 5.5) is reached, no further bio-acid is added. If maximum bio-acid is added (5 % per m^3 manure) with no effect, the system can be set to switch to an organic acid.

Dependent on the time when the daily acidification is set to run, manure is pumped into the storage tank. The manure is pumped to the storage tank until a preset minimum level in the mixing tank is reached. In case the farm delivers to a biogas facility, manure can be collected directly in the mixing tank.
All processes such as stirring, pumping, addition of bio-acid and pumping to the storage tank are controlled automatically to reach the decried pH level. A PLC based control unit is controlling the acidification process. Logging of all measured pH and temperature values are stored locally on PLC system, which can be accessed locally or by remote support. This gives an opportunity to continuously monitor and verify that the system works properly. An operational report can be downloaded for documentation.

The bio-acid used for acidification of the manure can contain organic acids such as acidic acid, lactic acid, formic acid, benzoic acid or an/or pre-fermented organic carbon rich such as molasses, beet pulp, ensilage or milk residues that can be further fermented to organic acids in the manure pit.
In this verification, pre-fermented beet molasses is used.

Online data logging
JH Agro control system logs all actions by the JH BioAcidification NH4+ system including:

- Process start time
- Process end time
- pH before bio-acid addition
- pH after process
- Acid consumption

Test Design

The JH BioAcidification NH4+ system was tested in Denmark by Danish Technological Institute, AgroTech, who carried out a case-control test in accordance with the VERA protocol at one commercial dairy production. Emissions were measured simultaneously at two separate

compartments at the same farm location. One of the compartments had JH BioAcidification NH4+ system while the other compartment did not and functioned as control/reference. Half way through the test period, after 6 months, the case and control compartment were switched to avoid any bias regarding even distribution of cows and heifers or house effects. Before test start and bio-acid addition, a pre-test was carried out to measure baseline ammonia emission from the two compartments. Emissions were calculated as mean kg NH_3/accessible floor area/year and kg NH_3/LU/year for the case and control compartments. The technology was tested at one farm location in a period of one year.

Emission calculations require the determination of ventilation rates. In naturally ventilated buildings, ventilation rates cannot be measured by fans but can be determined by use the tracer gas method.

The tracer gas used in this test was CO_2 produced by the animals. The production of CO_2 can be estimated from mainly the size of the animals and the milk production. The tracer gas method assumes even distribution of gases and that the dilution rate of CO_2 are equal to the one of NH_3.

The effect was measured over a period of 12 months covering measurements during summer and winter conditions. The primary performance parameter is ammonia. The technology was not assessed to have any negative effect on odour emission. In addition to the primary performance parameters a number of operational parameters were measured throughout the test period.

Test Results

Environmental Efficiency

Ammonia

The measured ammonia emission with and without the JH BioAcidification NH4+ at test site Rødekro are presented in table 1. The mean ammonia efficiencies and the overall effect on ammonia reduction during one year are presented in table 1.

Table 1: *The ammonia emissions are measured with Picarro in the exhaust air from the control and experimental units at test location Rødekro between 25 November 2017 and 29 October 2018. The 95 % confidence interval is given in brackets.*

	Ammonia emission				Efficiencies	
Location Rødekro	**Reference/Control**		**JH BioAcidification NH4+**		**Reduction, %**	
N=6	**Mean**	**Median**	**Mean**	**Median**	**Mean**	**Median**
g NH_3/d/LU	30.72	28.73	20.24	21.34	32.75	35.73
95% confidence	[24.6 – 36.2]		[17.2 - 23.6]		[22 – 43.6]	
Kg NH_3/year/LU	11.21		7.39		34.1	
g NH_3/d/m^2	2.95	2.76	1.96	2.04	32.29	33.21
95% confidence	[2.4 - 3.5]		[1.7 - 2.2]		[24.5 - 40.1]	
Kg NH_3/year/m_2	1.08		0.71		33.6	

Statistically significant difference, P<0.002 relative to the ammonia emission from the control unit.

Table 2: *The ammonia concentrations and emissions in g per day per livestock unit is measured with Picarro in the exhaust air from the control and experimental units at test location Rødekro between November 25 2017 and October 29 2018.*

Month	Control Emission g NH3/d/LU	JH BioAcidification NH4+ Emission g NH3/d/LU	Effect, %
November	24.70	13.89	44
February	27.79	17.23	38
April	42.17	22.12	48
June	36.49	24.28	33
September	29.68	23.37	21
October	23.48	20.55	12

Statistically significant difference, P<0.003 relative to the ammonia emission from the control units.

The ammonia emission from the dairy production that applied bio-acidification was on year average reduced with 34 %.

Operational parameters

Table 3: *Mean pH values in the measuring period, typical 4-5 days, during the 6 measuring periods.*

Months	Mean pH
November	5.7
February	5.6
April	5.5
June	5.5
September	5.9
October	6.0

Bio-acid consumption:

The consumption of bio-acid, in our case molasses, was measured and documented to a rate of between 2.5 % and 5 %, in relation to produced manure, during long term operation. Due to several shut downs and following startups, it was not possible to measure the bio-acid consumption during an entire year of operation. The system is set to a consumption of maximum of 5 % molasses which we for safety reasons will state as operation rate. Organic acid in the form of acidic acid was only used during startup.

Identified Side Effects

None observed.

Additional Results

None observed.

Operational Stability

The test proved that the JH BioAcidification NH4+ system had sufficient operational stability. The JH BioAcidification NH4+ system is delivered with a complete user manual, which describes relevant directions for system operation, maintenance and safety.

Particularly, the following issues shall be observed as described in the use manual:

- pH-level: The user shall monitor the pH-level
- Control and remedy alarms
- Use of Bio-acid (molasses): The user shall monitor and the amount of organic acid used and register the amount being purchased.
- Use of organic acid: The user shall monitor the amount of organic acid used and register the amount being purchased.
- Control of organic acid and bio-acid leftovers in tank
- Control of fluids via viewing window placed on the external hull of the tank
- Control manure level in the pit must be above agitator propeller at all time.

Amendment and deviation report

The test at Rødekro was carried out according to the test plan except three measuring periods which were moved due to summer holidays and logistics when the test and control units had to be switched and the manure had to be removed. Measure period 4; 4-11 June 2018 to was moved to 17-21 June 2018. Measure period 5; 9-16 July 2018 was moved to the 26-30 September 2018. Measure period 6; 10-17 September 2018 was moved to 23-29 October 2018.

***Table 4**: Service log from test site Rødekro*

Date	Deviation at site Rødekro
10.01.2018	High pH
17.01.2018	Foam creation
20.01.2018	Metering pump changed to cavity pump
01.02.2018	Machine pool emptied manure pit → agitator adds air to manure
12-19.09.2018	Machine pool emptied manure pit → agitator adds air to manure

On several occasions during the test period, JH Agro A/S have been called out to service the JH BioAcidification NH4+ system at Rødekro. First in January 2018 the system was not able to hold the pH threshold and the pH raised to above 6, due to insufficient bio-acidification. One week later the system was shut down because of foam creation. The problem was the metering pump that was clogged due to cold weather and thick molasses. When the weather got warmer, the pump suddenly delivered a lot of molasses which led to foaming. The pump was later removed and changed to a cavity pump, less sensitive to the density of the substrate.

In the beginning of February 2018, the farmer emptied his manure pits leaving the agitator propeller above the manure surface coursing aeration for the remaining manure. This resulted in fast degradation of the bio-acid, bad smells and a raise in ph. The same happened in September 2018 and each time the system have to be started again following a period where the pits were filled op with fresh manure. This resulted in high average pH for test period 6 and lower ammonia reduction. These incidences and the switching of units resulted in a bio-acid consumption that is not representative for normal operation.

The JH BioAcidification NH4+ system shall be inspected at least every 4 months and all necessary maintenance shall be carried out in accordance with the instructions from JH Agro A/S. pH-sensors are calibrated 3 times a year including 1 major service and 2 basic services.

Additional Information

No additional information.

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