ETV Verification Statement

Technology type	Technology for land application of animal slurry	
Application	Reduced ammonia and odour emissions	
Technology name	SyreN	
Company (vendor)	BioCover A/S	
Address	Veerst Skovvej 6 6600 Vejen Denmark	**Phone:** +45 2963 4936
Website	www.biocover.dk	
E-mail	mt@biocover.dk	

DANETV, The Danish Centre for Verification of Climate and Environmental Technologies, undertakes independent tests of environmental technologies and monitoring equipment.

DANETV is a co-operation between five technological service institutes, DHI, Danish Technological Institute, FORCE Technology, DELTA and AgroTech. DANETV was established with financial support from the Danish Ministry of Science, Technology and Innovation. Information and DANETV documents are available at www.etv-denmark.com.

AgroTech Verification Centre undertakes verifications of environmental technologies for the agricultural sector. The verifications and tests are planned and conducted in accordance with the guidelines for the ETV Pilot Programme currently being established by the European Union.

This verification statement summarizes the results from the ETV test of the SyreN system developed by BioCover A/S applied for reducing ammonia and odour emissions from land application of slurry.

Description of technology

The basic idea of the SyreN slurry application system is to add sulphuric acid and/or iron sulphate to animal slurry during land application. In a liquid, ammonium (NH_4^+) will be in equilibrium with ammonia (NH_3) in aqueous and gaseous forms as follows: NH_4^+ (aq) <—> NH_3 (aq) <—> NH_3 (gas). If the pH of the liquid is reduced the equilibrium is displaced to the left. Thus adding sulphuric acid to slurry reduces the pH of the slurry and thereby the potential for ammonia emission.

When iron sulphate ($FeSO^4$) is added to slurry Fe^{3+} will be reduced to Fe^{2+} which reacts with sulfide (S^{2-}) under formation of iron sulfide. Sulfide is one of the main contributors to odour from slurry. Therefore, addition of Fe^{3+} and the resulting precipitation of iron sulfide can lead to reduced odour emission from slurry application.

ENVIRONMENTAL TECHNOLOGY VERIFICATION

SyreN is an add-on system to be installed on existing slurry application machinery, normally consisting of a tractor and a slurry tanker. There are three main parts of the SyreN system:

1. Front tanks for storage of sulphuric acid and iron sulphate during land application
2. Terminal software for regulation of dosage of sulphuric acid and iron sulphate to slurry tanker
3. Pumps for addition of sulphuric acid and iron sulphate to slurry tanker.

Figure 1 shows two photos of the SyreN system installed on a tractor with a slurry tanker.

Figure 1. The SyreN-system includes three tanks installed on the front of the tractor. 1: Tank for iron sulphate. 2: Here the tank for sulphuric acid shall be placed. 3: Tank for water for cleaning the system.

Application of technology

The intended application of the SyreN technology is defined in terms of the matrix, the target and the effect of the slurry application system. The matrix is the type of material that the technology is intended for. Targets are the measurable properties that are affected by the technology. The effects describe how the targets are affected by the technology.

Matrix	The SyreN system was verified for the following matrices: • Cattle slurry applied to grass land • Pig slurry applied to winter wheat
Targets	For the SyreN slurry application system the targets of the applications are: • Odour concentration from cattle slurry applied to grass land • Ammonia emission from cattle slurry applied to grass land and pig slurry applied to winter wheat
Effects	• Reduced odour concentration following application of cattle slurry using the SyreN system with addition of iron sulphate compared to standard slurry application systems (trailing hoses). • Reduced ammonia emission following application of cattle slurry using the SyreN system with addition of sulphuric acid compared to standard slurry application equipment (trailing hoses). • Reduced ammonia emission following application of pig slurry to winter wheat using the SyreN system with addition of sulphuric acid compared to standard slurry application equipment (trailing hoses).
Exclusions	• The long term odour effect of addition of sulphuric acid and iron sulphate was not studied as part of this verification. • The effect on odour emission by addition of both sulphuric acid and iron sulphate at the same time was not studied as part of this verification. Only the effect of adding either sulphuric acid or iron sulphate has been studied.

ENVIRONMENTAL TECHNOLOGY VERIFICATION

Description of test

The SyreN slurry application system was tested at the fields of Research Centre Foulum, which is part of Faculty of Agricultural Sciences, Aarhus University. The test included data from four sampling days between 04.05.2010 and 15.06.2010. The test was undertaken in cooperation between staff from Aarhus University (ammonia emissions) and test staff from AgroTech (odour emissions).

To verify the odour reducing effect of using the SyreN system for addition of iron sulphate during land application the following four scenarios were tested and compared:

- Application of un-treated cattle slurry using trailing hoses (reference scenario 1)
- Shallow injection of un-treated cattle slurry (reference scenario 2)
- Addition of sulphuric acid to cattle slurry followed by land application using trailing hoses
- Addition of iron sulphate to cattle slurry followed by land application using trailing hoses

Odour emissions were measured by taking air samples above the land shortly after slurry application. To avoid heterogeneity of wind disturbance during sampling and to pre-concentrate odour samples slurry treated surfaces were covered by a static flux chamber system before air sampling. Samples were sent to laboratory and odour concentration measured by dynamic olfactometric analyses.

To verify the effect on ammonia emission from addition of sulphuric acid using the SyreN system the following three scenarios were tested for following application of cattle slurry on grass land and pig slurry on winter wheat:

- Application of un-treated slurry using trailing hoses (reference scenario 1)
- Shallow injection of un-treated slurry (reference scenario 2)
- Addition of sulphuric acid to animal slurry followed by land application using trailing hoses.

Ammonia emissions were measured by the micrometeorological mass balance method. This involves a measuring mast situated centrally in each experimental plot, and a background measuring mast located outside the plots for measurement of the background NH_3 levels. The ammonia emission from land applied slurry is highly depending on the meteorological conditions during and following land application. Hourly data for wind speed, temperature, incident solar radiation, atmospheric humidity and precipitation were therefore continually measured during the test period.

Verification results

This section summarizes the results of the test and verification as described in the test report and verification report respectively.

It is seen in table 1 that adding Fe^{3+} by the SyreN system reduced odour concentration in air sampled above the applied slurry from 627 to 320-363 $OU_E\ m^{-3}$ air compared to application of un-treated slurry with trailing hoses. This corresponds to a reduction of 49 % and 42 % respectively with an average of 46 %. Thus, addition of Fe^{3+} by the SyreN system is a relevant technology for areas where odour nuisance is a large problem (e.g. on fields close to towns).

It is also seen that odour concentration right after trailing hose application was unaffected (measuring day 1) or slightly increased (measuring day 2) by addition of sulphuric acid using the SyreN system. Lowest odour concentrations were measured after shallow injection of un-treated slurry. See figure 2.

Table 1. Average odour concentration measured in air sampled above cattle slurry land applied by trailing hoses, shallow injection and by the SyreN system with addition of sulphuric acid or iron sulphate (Fe^{3+}). The SyreN system was trailing hose application of slurry added between 1.9 and 2.9 l of sulphuric acid per 1000 l of slurry or 0.5 l of Fe^{3+} per 1000 l of animal slurry. Values shown in parentheses are standard error of means.

	Odour concentration, Odour units (OU_E) m^{-3} air				
Measuring day	Trailing hoses	Shallow injected	SyreN acid	SyreN Fe^{3+} a	SyreN Fe^{3+} b
1: 02.06.2010	903 (225)	320 (60)	853 (132)	-*	-*
2: 15.06.2010	627 (90)	310 (32)	737 (203)	363 (67)	320 (51)

* As the test of addition Fe^{3+} failed the first measuring day, this test was repeated twice the second measuring day.

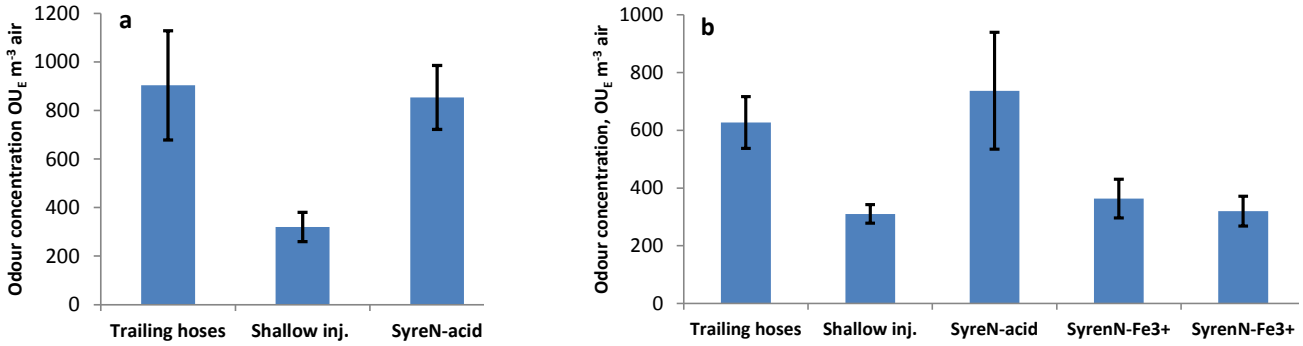

Figure 2. Odour concentration in air sampled above land applied cattle slurry. The cattle slurry was applied to grassland by trailing hoses, shallow injection, and by addition of sulphuric acid (SyreN-acid), or addition of iron sulphate (SyreN-Fe^{3+}) using the SyreN system. Diagram a (left) shows the results from measuring day 1 (02.06.2010) and diagram b (right) shows the results from measuring day 2 (15.06.2010). All data were sampled seven minutes after land application. Error bars show the standard error of means.

In table 2 the results from measurement of ammonia emissions are summarized. It is seen that for pig slurry applied to winter wheat addition of sulphuric acid using SyreN reduced ammonia-N loss from 23 % to 15 % of applied NH_4-N compared with un-treated pig slurry applied to land using trailing hoses. This corresponds to a reduction of 35 %.

Table 2. Average ammonia emission from pig and cattle slurry following land application by trailing hoses, shallow injection and the SyreN system. The SyreN system was trailing hose application of slurry added between 1.9 and 2.9 l of sulphuric acid per 1000 l of slurry.

Type of slurry	Crop	**NH_3-N loss, % of applied NH_4-N**		
		Trailing hoses	Shallow injected	SyreN
Pig slurry	Winter wheat	23	11	15
Cattle slurry	Grass land	41	18	21

When cattle slurry was applied to grass land after addition of sulphuric acid by the SyreN system ammonia emission was reduced from 41 % to 21 % of applied NH_4-N compared to un-treated cattle slurry applied to grass land using trailing hoses. This corresponds to a reduction of 49 %. Both for pig slurry and cattle slurry the lowest ammonia-N losses were measured when the slurry was applied to land using shallow injection.

Quality assurance

The test and verification have been performed according to the AgroTech Test Centre Quality Manual. As a part of the quality assurance an internal and an external technical expert provided review of the planning, conducting and reporting of the verification and tests.

Signed by Lars B. Kjær AgroTech management representative	Date	Signed by Thorkild Q Frandsen Verification responsible, AgroTech	Date