Gas Innovation Fund

Gas Networks Ireland – GlasPort Bio

Final Project Report

March 2023

Project Overview:
GlasPort Bio are developing GasAbate, a novel manure additive to prevent gaseous emissions from stored manure and slurry. Prevention of greenhouse gas (methane, nitrous oxide, carbon dioxide) and other gases (ammonia, hydrogen sulphide) shall allow both improved environmental aspects of manure management on farm, but also greater nutrient retention in the slurry for onward processing and use.

This project therefore shall investigate 4 key aspects:

1. Validation of GasAbate as a means of reducing gaseous emissions from stored pig slurry
2. Validation of increase biogas yield following anaerobic digestion (AD) of treated material at medium-scale AD
3. Validation of increased fertiliser value of digestate
4. Validation of economic and environmental savings by all stakeholders through use of GasAbate from storage through to AD and onward fertiliser usage

RESULTS

1. Validation of GasAbate as a means of reducing gaseous emissions from stored pig slurry

Dynamic storage study:
Comparison studies were carried out in 1m^3 intermediate bulk containers (IBCs) to investigate the effect of GasAbate to reduce emissions from stored slurry over a 31-day period using the dynamic chamber method. Briefly, a set air flow is applied across the surface of a closed IBC to mimic pig shed conditions. The inlet and outlet gas characteristics are continually monitored to quantify the emissions lost during slurry storage. A control (untreated) and test IBC (treated with GasAbate) as shown in Image 1 were directly compared.

Image 1 Dynamic chamber comparison –Test (treated with GasAbate) vs. Control (untreated)

The graphs in Figure 1 show the cumulative CH_4 and CO_2 emissions for control and test IBCs demonstrating the impact of GasAbate in reducing emissions. Treatment with GasAbate resulted in an average 75% reduction in CH_4 emissions and 43% reduction in CO_2 emissions. The reductions achieved through GasAbate treatment represent a conservation of biogas potential in treated slurry. This retained carbon can then be harnessed through anaerobic digestion.

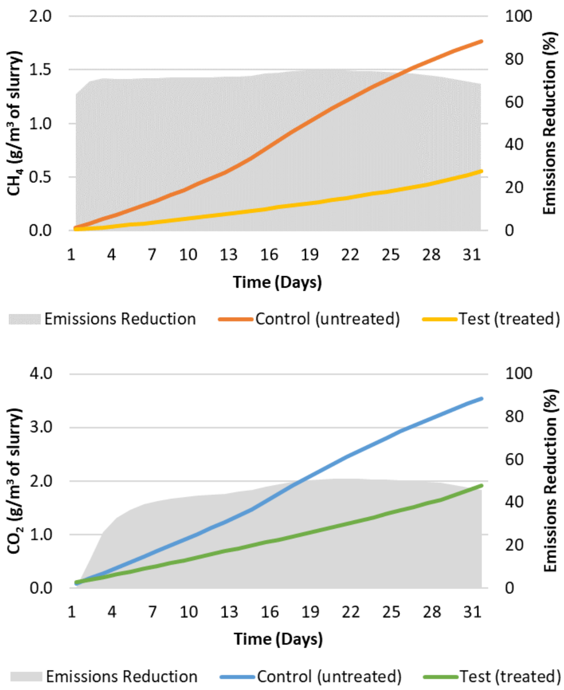


Figure 1 Cumulative methane (CH_4) and carbon dioxide (CO_2) emissions and reductions from test and control IBC tanks

2. Validation of increase biogas yield following anaerobic digestion (AD) of treated material at medium-scale AD

Pilot-scale digester study:

Slurry from the dynamic storage study was used as substrate for a comparison study in two 100 litres continuously stirred tank reactor (CSTR) type anaerobic digesters, Image 2. The study aimed to demonstrate the biogas benefit imparted through slurry treatment with GasAbate (test) in comparison to untreated slurry (control) following 31 days of storage. The digesters were seeded with digestate obtained from the on-site full scale anaerobic digester and operated in batch mode with the slurry from the dynamic storage study. Digester temperatures were maintained at 35°C. Gas production volumes were continually monitored and gas characteristics were assessed periodically.

Image 2 Pilot-scale digesters –Test (treated with GasAbate) vs. Control (untreated)

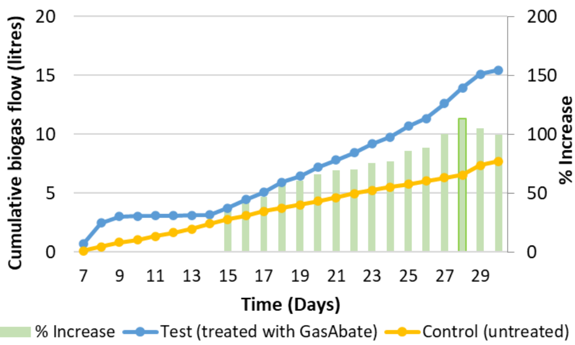


Figure 2 Cumulative biogas production and % increase - Test (treated with GasAbate) vs. Control (untreated)

Figure 2 illustrates the difference in biogas production and cumulative volume following 30 days of digestion. The slurry stored following the 31-day dynamic storage study demonstrates the benefit of GasAbate treatment through conservation of organic carbon in slurry. By the completion of the digester run the cumulative biogas volume for the treated slurry (Test) was double the cumulative volume for the untreated (Control) slurry.

Full-scale digester study:

In order to assess the benefit for gas production onsite a large tank treatment study was undertaken. This involved manually treating the slurry below three small, slatted tanks below weaner sheds with the treated slurry then being processed through the onsite full-scale digester.

The tanks to be treated were emptied and treated with GasAbate as they filled over a two-month period. When the tanks were full the treated slurry was removed from the tanks and immediately sent for digestion. The volume treated provided sufficient slurry substrate for 9 days of digester input. This provided sufficient volume to fully assess the biogas benefit over a sustained period.

The introduction of treated slurry provided an instant biogas production increase from the digester which was sustained for the 9 days of operation. The graph below summarises the biogas yield (m^3 biogas/m^3 of slurry) pre-test (untreated slurry) and during digestion of treated slurry. For further context, the highest biogas yield to have been previously achieved onsite is also included.

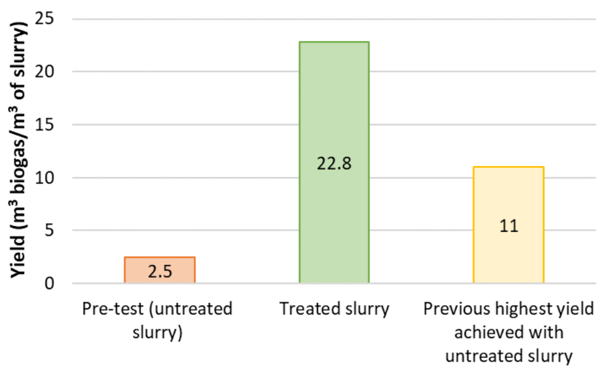


Figure 3 Biogas yield (m^3 biogas/m^3 of slurry), pre-test, with treated slurry and previous highest yield achieved with untreated slurry

The increase in biogas production between per-test and treated slurry was dramatic rising to 22.8 m3/biogas/m3 of slurry digested from 2.5. The biogas production rate achieved onsite with the full -scale digester can be quite variable due to the carbon lost through gas emissions during storage and based on historical data the pre-test biogas production rate was low. However, the highest biogas yield to have been previously achieved onsite was half that achieved with the treated slurry during this assessment. This difference between treated and untreated is in agreement with the pilot-scale digester study result.

3. Validation of increased fertiliser value of digestate

Following pilot-scale AD digestate from treated and control rigs were analysed for nutrient content. This demonstrated a higher nutrient content retained in digestate from treated slurry compared to digestate from untreated slurry.

	Untreated control	Additive treated	Difference from untreated control
Total Carbon (%)	2.76	2.94	+ 6.5 %
Ammonia Nitrogen (mg/kg)	3735	3731	-0.1 %
Kjeldahl Nitrogen (%)	0.48	0.51	+ 6.3 %
Phosphorus (mg/kg)	565	680	+ 20.4 %
Potassium (mg/kg)	2755	3107	+ 12.8 %
Total Sulphur (mg/kg)	333	402	+ 20.7 %
Magnesium (mg/kg)	275	309	+ 12.4 %
Zinc (mg/kg)	36.2	47.2	+ 30.4 %
Calcium (mg/kg)	937	1231	+ 31.4 %
Copper (mg/kg)	23.9	31.4	+ 31.4 %
Sodium (mg/kg)	863	977	+ 13.2 %
pH	8.4	8.3	-1.2 %

4. Validation of economic and environmental savings by all stakeholders through use of GasAbate from storage through to AD and onward fertiliser usage

Environmental Impact

A Climate Impact Assessment/Forecast was conducted on a hypothetical pig farm with the following characteristics: **3,200 sows generating 16,000 tonnes of pig slurry per year, generating biogas from treated manure which is upgraded to biomethane with digestate used as fertiliser.** The effect of using the GasAbate additive is modelled in this environmental impact assessment with the following factors taken into account:

- ***(a) GasAbate production*** *(the energy required to generate the GasAbate additive).*
- ***(b) Transport of GasAbate components to farm site*** *(transport from place of manufacture to place of use).*
- ***(c) Reduced fertiliser transport from offsetting fertiliser purchase*** *(improvement in N, S content of digestate means that less mineral fertiliser needs to be purchased and transported).*
- ***(d) Reduced environmental emissions from slurry management*** *(c.80% reduction in greenhouse gas emissions through the use of GasAbate, as evidenced from on-farm trials).*

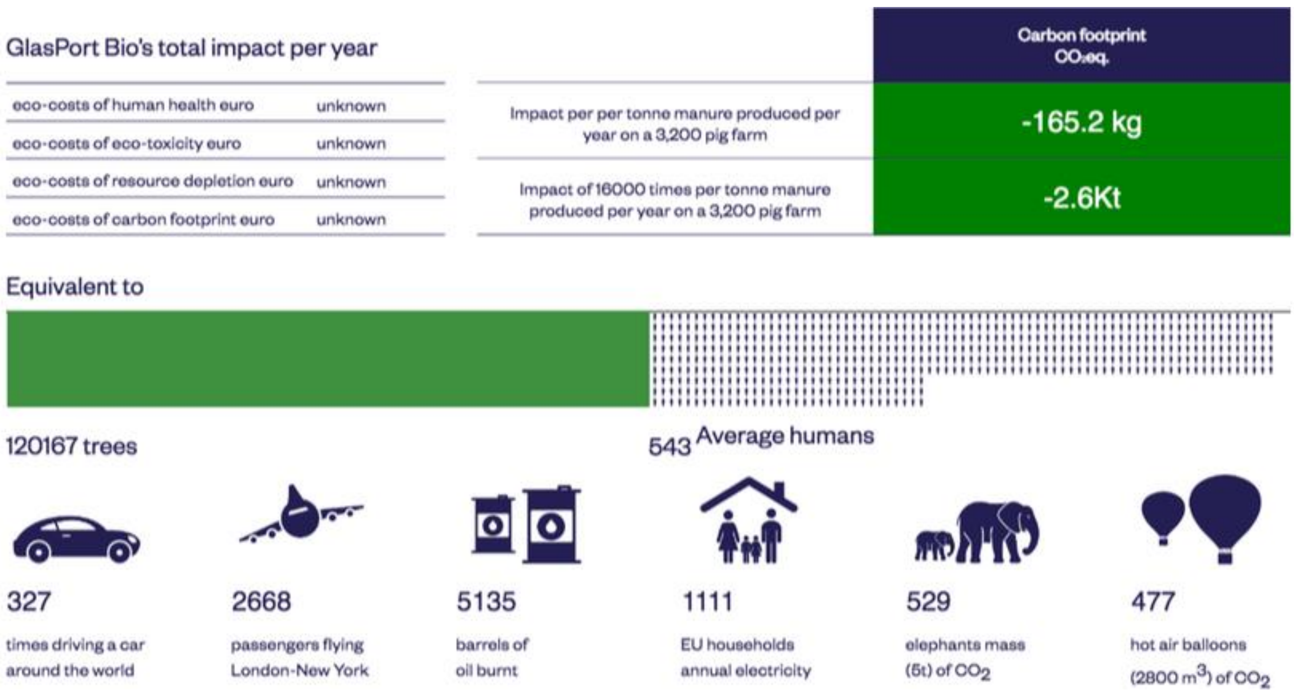
(e) ***Increased emissions from pumps using to apply GasAbate*** *(environmental impact of using pumps to apply the GPB additive to manure).*

(f) ***Biomethane production using GasAbate treated slurry*** *(an upgrading of biogas to biomethane scenario is modelled in this scenario, and an improvement in biogas production per mass of slurry when using GasAbate is factored in – this is taken to be a 50% retention of biogas to represent the trapping of carbon within the slurry material which would otherwise be lost to the environment in untreated manure).*

(g) ***N- and S-content of GasAbate treated manure used as AD feedstock*** *(losses of all gases is halted under treatment and so increases in the content of Nitrogen and Sulphur is included in the modelling of environmental impact of the additive).*

The output report from this modelling shows the **reduced carbon footprint (CO_2eq.) per tonne of manure produced (165.2kg)** and the impact of the use of the GPB additive on 16,000 tonnes of manure which is the approximate annual manure yield from 3,200 pigs. The **2,600 tonne CO_2 eq. savings predicted** is equivalent to **5,135 barrels of oil being burnt or 120,167 trees etc.!**

This climate impact forecast is carried out on https://impact-forecast.com/, an independently validated assessment tool where specialists and software solution help innovators to measure and improve their climate impact. The tool uses impact data and principles from Life Cycle Assessments (LCA) and make them useful for SMEs to calculate their CO_2 footprints and environmental impact. GlasPort Bio have conducted impact assessments on the platform for cattle and pig models and have achieved the highest possible impact assessment from independent validators of: **plausible, positive and significant.** GlasPort Bio's Director of Business Development, Mr. Andy Leyland, GPB: Climate Impact Forecast was asked to present our company's modelling for the Climate-KIC, funded by the EC.



Financial Impact

A business case is presented for a relevant pig farm in Irish with **3,200 pigs** operating anaerobic digestion (AD) with upgrading to biomethane onsite. This is the financial impact which corresponds to the environmental impact study also presented in this report.

Table 1: Business case pig slurry to biomethane

No. pigs	Manure (t)	GasAbate required (L)	Cost to farmer (€)	Savings to farmer (€)	Biomethane revenue (€)	Farm return (€)
3,200	9,600	16,704	25,056	4,800	112,000	**91,744**

The business case is built upon a pig farm of 3,200 animals generating 3 tonnes of slurry per year, treatment of which would cost the farmer €25,056 per annum in the purchase of GasAbate. Savings to the farmer include €4,800 for the improved Nitrogen content of manure which can offset the purchase of fertiliser; €112,000 biomethane revenue is also factored into the business case as we are modelling the upgrading of biogas using treated manure to generate biomethane. **Overall, the farm return is €91,744 per annum.**
Additional savings to the farmer e.g., through enhanced animal health and performance (improved feed efficiency/reduced finishing time), nor through potential sustainability bonuses/carbon credit generation has not been factored into this table.

Conclusion:

Through this project GasAbate has been validated as an effective means of reducing GHG and other gaseous emissions from stored pig slurry. Given that the majority of GHG emissions from the pig sector are largely due to manure management, GasAbate offers an immediate and facile route for the sector to greatly reduce its carbon footprint.

The project has also validated the impact of GasAbate on nutrient retention in the slurry allowing for greater valorisation and reuse of such nutrients. Pig slurry has long be suggested as a feedstock for AD. However due to the high volatility of pig slurry with respect to gaseous emissions, even after a short period of storage (7-14 days) the biogas potential is greatly reduced, rendering the economics of a slurry-based AD challenging. Use of GasAbate acts to reduce such nutrient losses, in particular retention of carbon from reduced methane emissions. This carbon is available in AD to allow for enhanced biogas production. From a medium-scale AD pilot an increase of 150% was seen in pig slurry treated with GasAbate compared to an untreated control. This was also shown at a full-scale pig farm and commercial AD plant, where treated slurry yielded a >9x increase in biogas compared to untreated and more than 2x greater than the highest yield recorded at this AD plant. Such increases completely change the economic proposition of slurry-based AD.

From reduced emissions of other gases e.g., ammonia, hydrogen sulphide, not only are odours greatly reduced from slurry storage, but these nutrients are also retained in both treated slurry and digestate from treated slurry. Nutrient analysis validated this nutrient retention, while agronomic studies demonstrate that these nutrients are available to the plants allowing for enhanced agronomic performance.