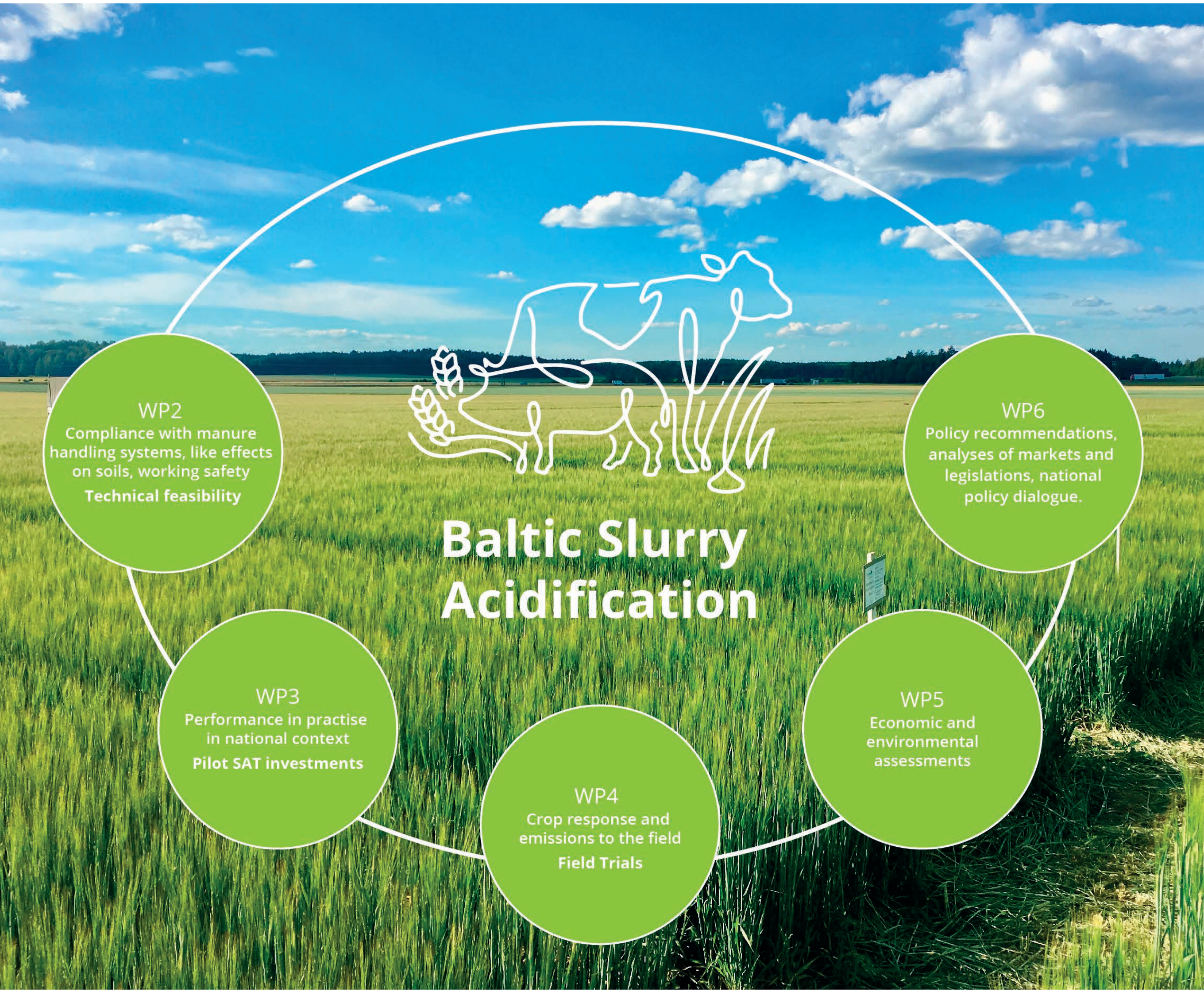
Baltic Slurry Acidification

EU STRATEGY FOR THE BALTIC SEA REGION
FLAGSHIP

Interreg
Baltic Sea Region
Baltic Slurry Acidification

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND



Livestock manure is the main source of ammonia-nitrogen emissions in the Baltic Sea Region, which through atmospheric deposition results in a significant amount of nitrogen entering the Baltic Sea. Ammonia emissions also threaten human health through its key role in the formation of secondary particulate matter.

Acidification is a well-known technique used to reduce ammonia loss from livestock manure. When the pH of the manure is lowered, emissions decrease and nitrogen is stabilized into a plant-available form. Farmers benefit from the increased fertilizer value of slurry and the decreased need to invest in mineral nitrogen and sulphur fertilizers. The environment benefits from reduced ammonia-nitrogen emissions and reduced eutrophication.

Slurry acidification techniques (SATs) can be used at different stages of manure handling on pig and cattle farms. The techniques can be divided into three types:

- In-house acidification of livestock slurry
- In-storage acidification of stored livestock slurry
- In-field acidification of livestock slurry during field spreading.

Baltic Slurry Acidification project analyzed and studied different aspects of the techniques and their benefits to advance the implementation of SATs. The work was divided to five parts.

All reports referenced in this brochure can be found of the project website: www.balticslurry.eu

In-house SAT in Denmark, to where the project made an excursion. Photo: Erik Sindhöj, RISE

In-storage equipment in use in Poland. Photo: Jan Barwicki, ITP

Percostations on field. Photo: Tiit Plakk, ECRI

WP2

Technical feasibility studies

WP2 identified technical issues, bottlenecks and other barriers that may hinder the implementation of slurry acidification techniques in the Baltic Sea region countries.

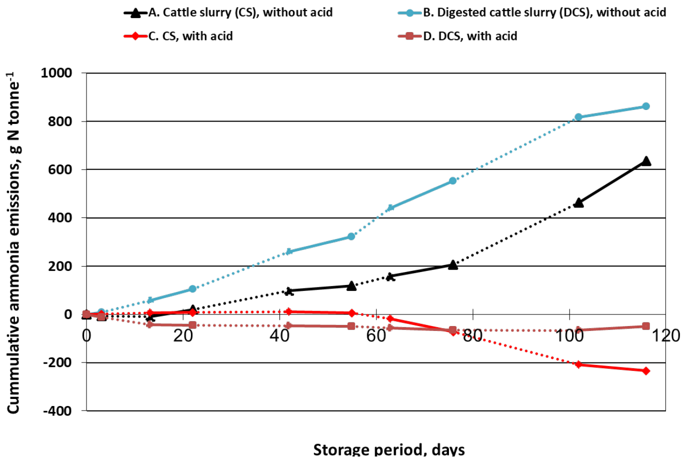
The following conclusions are a result of the WP2 work:

- In-field and in-storage technologies are the easiest to implement. In-house technology is best implemented in connection to the construction of a new animal barn.
- Sulphuric acid is a strong acid and therefore dangerous to handle. WP2 has created a guide "Working environment and safety" to help to cover safety issues. WP2 recommends both choosing a technique with little or no risk of contact with acid and taking a variety of other precautionary methods.

Experimental set up with containers and masts for ammonia measurements with passive flux samplers. Photo: Lena Rodhe, RISE

- The amounts of acid required to acidify the slurries to a specific pH level varied widely between slurry types.
- Research about the impact of acidified slurry on soil showed that the acidified slurry induces more soluble salts into soil solution compared to non-treated slurry. Some of these compounds are more movable, which causes risk of faster leaching.
- Acidification of slurry with sulphuric acid will, in most cases, increase the need for liming, which means additional costs. At an application rate of 45 m^3 per ha, the acidified pig slurry (pH 6.2) compared to the non-acidified slurry (pH 7.9) lowered pH of acidic soil (pH 5) by 0.1 units, which correspond to a liming demand of 0.2–0.4 tonnes per ha of calcium carbonate (100% efficiency).
- The most obvious benefit of acidification is its ability to reduce ammonia emissions from slurry, both from storage and after field application when enough acid is used.

Sensors on cattle slurry. Photo: Tiit Plakk, ECRI



Cumulative ammonia emissions from cattle slurry and digested cattle slurry, without and with acid addition to pH 5.5 during four months of storage.

The first investment in the project was Br. Göransson's in-field spreader. Here its inauguration in Borgeby agricultural fair in Sweden. Photo: Kaj Granholm

WP3

Pilot investments in slurry acidification techniques

WP3 organized investments in pilot installations of various slurry acidification techniques. The activities included planning the investments, organizing the procurement, implementation of use of SATs, dissemination of information.

The specific SATs were procured in accordance with local legislation of each particular country, the feasibility considerations and within the available budget limitations of project.

A total of nine separate procurements were done in six investment projects in six countries. There were two types of acidification equipment procured during the process: five in-field and one in-storage.

Country	Partner	Type of SAT
Estonia	Estonian Crop Research Institute (ECRI)	in-field
Latvia	Lauku Agro Ltd	in-field
Germany	Blunk GmbH	in-field
Lithuania	Lithuanian University of Health Sciences (LUHS)	in-field
Poland	Institute of Technology and Life Sciences (ITP)	in-storage
Sweden	Br. Göransson AB	in-field

A total budget of € 1,281,034 was used and the investments are expected to save the environment from 66,980 kg of nitrogen annually by reducing ammonia emissions. The investments should reduce the use of nitrogen mineral fertiliser. The use of sulphuric acid will also reduce the costs for purchase of sulphuric mineral fertiliser.

The report 3.1 Feasibility studies presents issues, from legislation to local conditions, which were considered in each case when planning the installations. The report also describes the investments in detail.

The fields used for testing or demonstrating slurry acidification in fields can be seen in Googlemaps, link https://bit.ly/2t03DuX.

WP4

Field trials

Field trials comparing acidified slurry (AS) with raw slurry or mineral fertilisers for fertilising ten different crops were carried out in seven Baltic Sea Region countries: Sweden, Finland, Estonia, Latvia, Lithuania, Poland and Germany. The activities were performed over a period of 1 to 3 years (2016–2018). The parameters for evaluation of field trials with AS were ammonia emission, crop yield (dry matter, protein content), plant health, soil pH, soil microflora and leaching. Trials were carried out on two different levels: scientific and as demonstration.

- The trials concluded that AS reduces ammonia emissions during field spreading of slurry significantly, i.e. with 40–88 % within 24 hours (PL, DE, LV). The yield response was not consistent, whereas the climate conditions for most trials were atypical. 2018 was dominated by heavy drought and high temperatures, with availability of water being more limiting for crop yields than the availability of plant nutrients.
- Seven trials (SE, PL, DE, LT) showed higher yields, and eight trials (SE, EE, FI, DE, LV) showed low impact to the yields.
- Acidified slurry (or acidified digestate) increased nitrogen uptake in crops (SE, PL, DE). Moreover, it was noticed that acidified slurry from pigs reduced the occurrence of leaf diseases (Septoria leaf spot and tan spot, EE) or improved the general quality of plants (PL).
- In addition, according to studies (PL, EE, LV, LT), the one-year use of acidified slurry had no significant effect on the potential of carbonate soil acidification (compared to other types of fertilizers) or microbiological activity of the soil.

In-field slurry spreader with acid tank in Germany. Photo: Frank Steinmann, LLUR

WP5

Economic aspects of slurry acidification

The economic aspects of slurry acidification play a crucial role in the farmer's decision to choose one of acidification technologies (SAT) or some other solution to minimise ammonia emission from slurry. The models composed within the project compare different solutions. Models, calculation data, methods and results are presented in the report "Economic aspects of slurry acidification".

SATs decrease ammonia emissions by 49–64%. Reduced emissions mean that farmers save nitrogen in slurry. Without SATs, farmers lose nitrogen from the slurry through ammonia volatilization: 8–30% from pig or cattle house, 10–25% from open storage and 40–70% from non-tilled fields.

In-house SAT reduces nitrogen loss from ex-animal, in-storage and in-field SATs on ex-storage slurry, thereby reducing the need of mineral nitrogen fertiliser.

With SATs, farmers have the possibility to save in mineral nitrogen fertiliser costs in the range of 0.77–2.10 € for each cubic meter of slurry used. Typically, an average of 30 m^3 of slurry is applied per ha.

In these examples, slurry pH is lowered using sulphuric acid. One litre of sulphuric acid contains 0.56 kg sulphur and consequently 1.5–2.5 kg of sulphur is applied with a cubic-meter of acidified slurry. It decreases the cost of mineral sulphur fertiliser by 0.8-1.4€ /m^3, if slurry is applied according to the crop's need.

The investment cost of an acidification system depends on the chosen SAT. However, the main cost factor is the price of sulphuric acid. Here a reference price of 128 € per 1000 kg of acid (including tank truck delivery) is used. Additionally, it is calculated that the use of acidified slurry raises liming cost by 0,11 €/m^3.

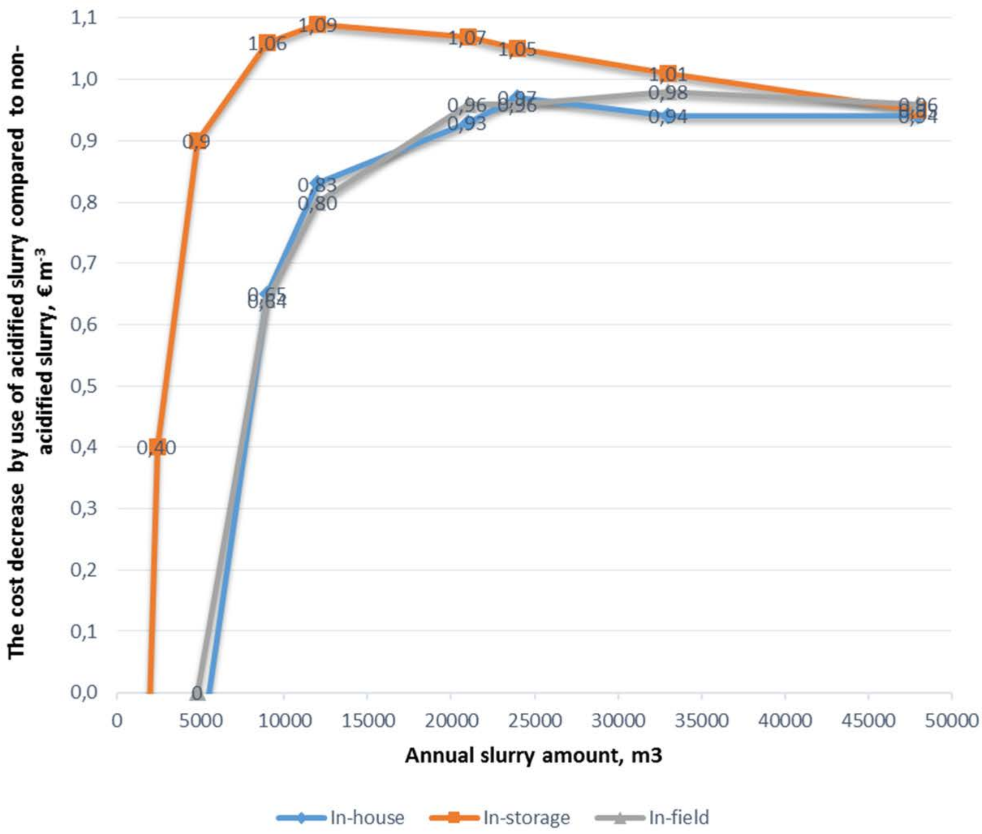
The graph on the next page illustrates the cost-benefit of SATs in bigger slurry amounts compared to band-application and disc-harrowing (within <12 h) of non-acidified slurry.

As each situation is unique, a careful analysis with local parameters and future prices should be performed before deciding on a SAT investment or SAT use on the farm. The farm level savings do not always cover cost of acidification, so society must take some of the burden as a compensation for reduced ammonia emissions.

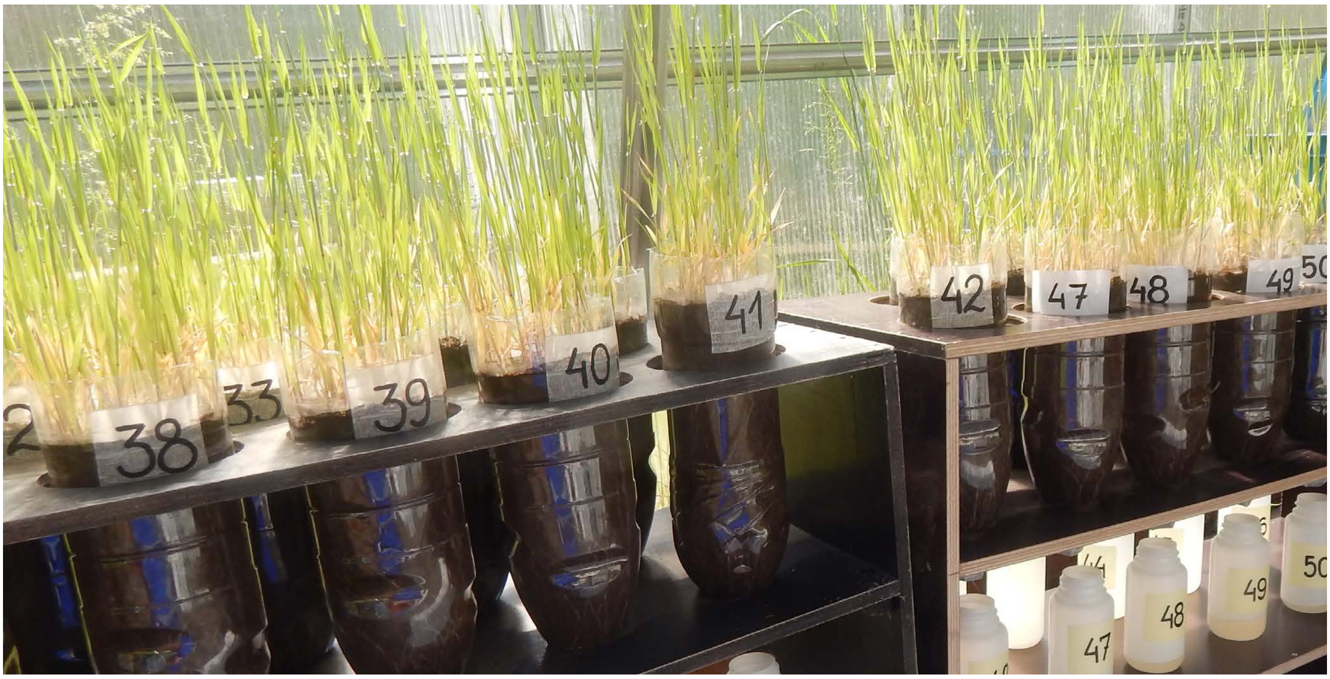
Example of estimated economic impacts of using SATs, based on Finnish pre-conditions.

SAT	In-house, cattle	In-house, pig	In-storage		In-field	
Slurry amount and animal amount	12,000 m³ per year 500 cow places	9 000 m³ per year, 18 000 fattener yearly	21 000 m³ per year		33 000 m³ per year	
Investment cost, €	102 000	230 000	14 000		73 000	
Acid price with delivery, € l^{-1}	0.24 (truck)	0.24 (truck)	0.29 (IBC)		0.29 (IBC)	
			Cattle slurry	**Pig slurry**	**Cattle slurry**	**Pig slurry**
Acid amount, l m^{-3}	4.5	3.5	3.6	3.0	3.0	2.6
Acid cost, € ha^{-1}	32	25	31	26	26	23
NH_3 emission reduction	50 %	64 %	55 %	55 %	49 %	49 %
N saving, kg ha^{-1}	41	77	31	36	28	32
N cost saving, € ha^{-1}	34	63	26	30	23	27
S cost saving € ha^{-1}	42	33	33	27	27	24
Cost benefit of SAT, € ha^{-1}	**25**	**47**	**32**	**41**	**29**	**38**

Cost savings include handling costs of mineral fertiliser: delivery to farm, storage, loading, transport to the field and spreading.



The cost decrease (€$^{m-3}$) by use of cattle slurry acidification compared to disc-harrowing <12 h after band-application of non-acidified slurry.



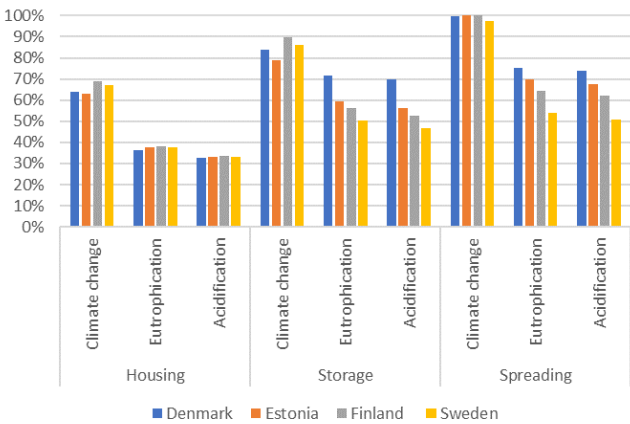
Lysimetric tests for slurry done in Estonia. Photo: Valli Loide, ECRI

WP5

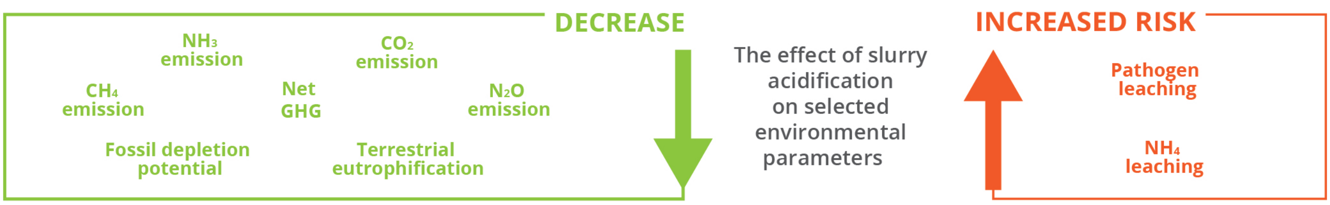
Environmental considerations of SATs

Published evidence about the environmental aspects of slurry acidification concludes that acidification decreases the environmental burden, largely due to reductions in ammonia emissions, especially so for in-house acidification. SATs also have a net positive effect in reducing greenhouse gas emissions and have been found to reduce leaching of total organic carbon. For nitrous oxide (N_2O), the evidence on effects of acidification is inconclusive. The main risk associated with slurry acidification is nutrient and pathogen leaching and higher survival rates of some pathogens due to the lower slurry pH. Since the highest risk of pathogen leaching is immediately after slurry application, slurry application should be avoided when rainfall is expected. To reduce risk of plant root and groundwater contamination with E. coli bacteria, surface application of slurry is recommended. As acidified slurry can be applied on the surface without the risk of ammonia losses, acidification can be also a good method of reducing the risk of contamination by E. coli.

These findings in scientific literature are, for the most part, confirmed by the project's system analysis for Denmark, Estonia, Finland and Sweden regarding environmental impact of global warming, eutrophication and acidification. The parameters include energy use, acid use and liming, but exclude saved mineral fertilisers. Ammonia emissions dominate effect on eutrophication and acidification and methane emissions dominate the effect on global warming.



Environmental effects from system analysis, as a percentage compared to non-acidified slurry.



Environmental effects of slurry acidification, based on publications.

Policy dialogues: Danish Environmental Technology Association and Organe Institute organised a four-hour long roundtable discussion about possibilities and challenges in relation to slurry acidification and its impacts on climate change and air quality. Photo: Henning Foged

WP 6

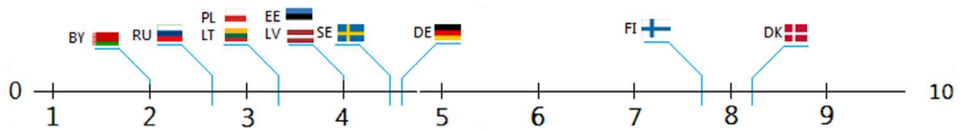
Policy recommendations and analyses of markets and legislation

Using slurry acidification to its fullest potential in the region would have a positive net economic effect of a total of 2.2 billion euros annually. In addition, slurry acidification could contribute with an estimated nitrogen abatement value of 147 million euros per year, related to the aquatic environment, and positive healthcare sector effects in Russia and Belarus.

Acidifying the total estimated weighed potential of slurry (about 234 million tonnes in the entire region) would reduce ammonia emissions by 167.1 Kt annually. For the eight EU countries in the region, the potential reductions (154.5 Kt) correspond to 80% of the reductions needed to reach the 2030 national emission targets for ammonia. Consequently, the investments would mean reductions of atmospheric nitrogen deposition in the range of 56,000 – 91,000 tonnes or in the level of 5-10% of current nitrogen loads to the Baltic Sea for all countries combined. In addition, the greenhouse gas emission would be reduced with 1.5 Mt CO_2e. This would roughly be 1% of the farming sectors share of greenhouse gas emission ceilings for 2030.

For most countries in the region, the mentioned effects would be sufficient for meeting ammonia emission ceilings and furthermore contribute substantially to reduce greenhouse gas emissions and nitrogen loads to the Baltic Sea. However, it is necessary to implement economic and legal incentives to ensure farmers' willingness to provide the mentioned environmental services of using slurry acidification.

Findings are based on analyses of market conditions and legal frameworks throughout the Baltic Sea region, as well as on technical research on slurry acidification related issues. EU Member States in the Region are recommended to establish national expert groups to further explore ways for implementing their slurry acidification potential.



Feasibility of slurry acidification in relation to current legal frameworks and support systems in the Baltic Sea Region countries. The figure is based on subjective scoring of qualitative information.

Spider webs are used for visualising the slurry acidification market potential, here with Germany used as example. The figure is based on subjective scoring of qualitative market information.

Summary

Baltic Slurry Acidification project partnership has studied and analysed different aspects of slurry acidification in the Baltic Sea region. All the reports and articles can be found in www.balticslurry.eu. Here is the summary of the project and its findings:

- Baltic Slurry Acidification has completed a 360 degree assessment of the conditions for slurry acidification techniques (SATs) implementation in the Baltic Sea Region
- Field tests and scientific literature indicate no harm to soil from applying acidified slurry
- No major barriers which could not be overcome in the EU countries
- Political incentives for implementation are needed
- Acid price and service logistics are key factors affecting the economics of using SATs locally and nationally.
- SATs include economic costs for the farmer, either in the investment cost or service cost when using a contractor. This must be compensated in order to advance SAT use.
- We recommend EU countries to establish national expert groups to look into implementation of slurry acidification for ammonia emission reduction as one additional measure in the palette of agri-environment measures
- Possible compensation mechanisms need to be considered and these must accommodate SAT use both as a farm investment or as a contracted service

Baltic Slurry Acidification

Baltic Slurry Acidification is an agro-environmental project financed by Interreg Baltic Sea Region under the priority area Natural resources and specific objective Clear Waters. The aim of the project is to reduce nitrogen losses from livestock production by promoting the use of slurry acidification techniques in the Baltic Sea Region and thus to mitigate eutrophication of the Baltic Sea. The project was implemented in the period March 2016 - February 2019.

www.balticslurry.eu

Project Partners

Research Institutes

- **Lead Partner: Research Institutes of Sweden – RISE** | Sweden
- **Animal Science Institute of Lithuanian University of Health Sciences** | Lithuania
- **Estonian Crop Research Institute** | Estonia
- **Institute of Technology and Life Sciences – ITP** | Poland
- **Organe Institute ApS** | Denmark

Regional Upper Public Authority, Federal State Agency

- **State Agency for Agriculture, Environment and Rural Areas of the German Federal State Schleswig-Holstein – LLUR** | Germany

Public and private advisory services

- **Agricultural Advisory Center in Brwinow Branch Office in Radom – CDR** | Poland
- **Association of ProAgria Centres** | Finland
- **Latvian Rural Advisory and Training Centre** | Latvia
- **Lithuanian Agricultural Advisory Service** | Lithuania
- **The Rural Economy and Agricultural Society** | Sweden

Interest Groups

- **Baltic Sea Action Group – BSAG** | Finland
- **Union "Farmers Parliament" – ZSA** | Latvia

End users (Farmers & Contractors)

- **Blunk GmbH** | Germany
- **Br Goransson** | Sweden
- **Lauku Agro** | Latvia
- **Vecsiljani** | Latvia

Partners funded by the Swedish Institute

- **Institute for Engineering and Environmental Problems in Agricultural Production – branch of Federal State Budgetary Scientific Institution "Federal Scientific Agroengineering Center VIM – IEEP – branch of FSBSI FSAC VIM** | Russian Federation
- **Northwest Research Institute of Agricultural Economics and Organization – NWRIAEO** | Russian Federation
- **Scientific and Practical Centre of National Academy of Sciences of Belarus for Agricultural Mechanization – Belagromech** | Belarus

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