MANURE HANDLING, STATE OF THE ART CONCERNING METHANE AND NITROUS OXIDE EMISSIONS

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KSLA 15 juni 2022

Research Institutes of Sweden

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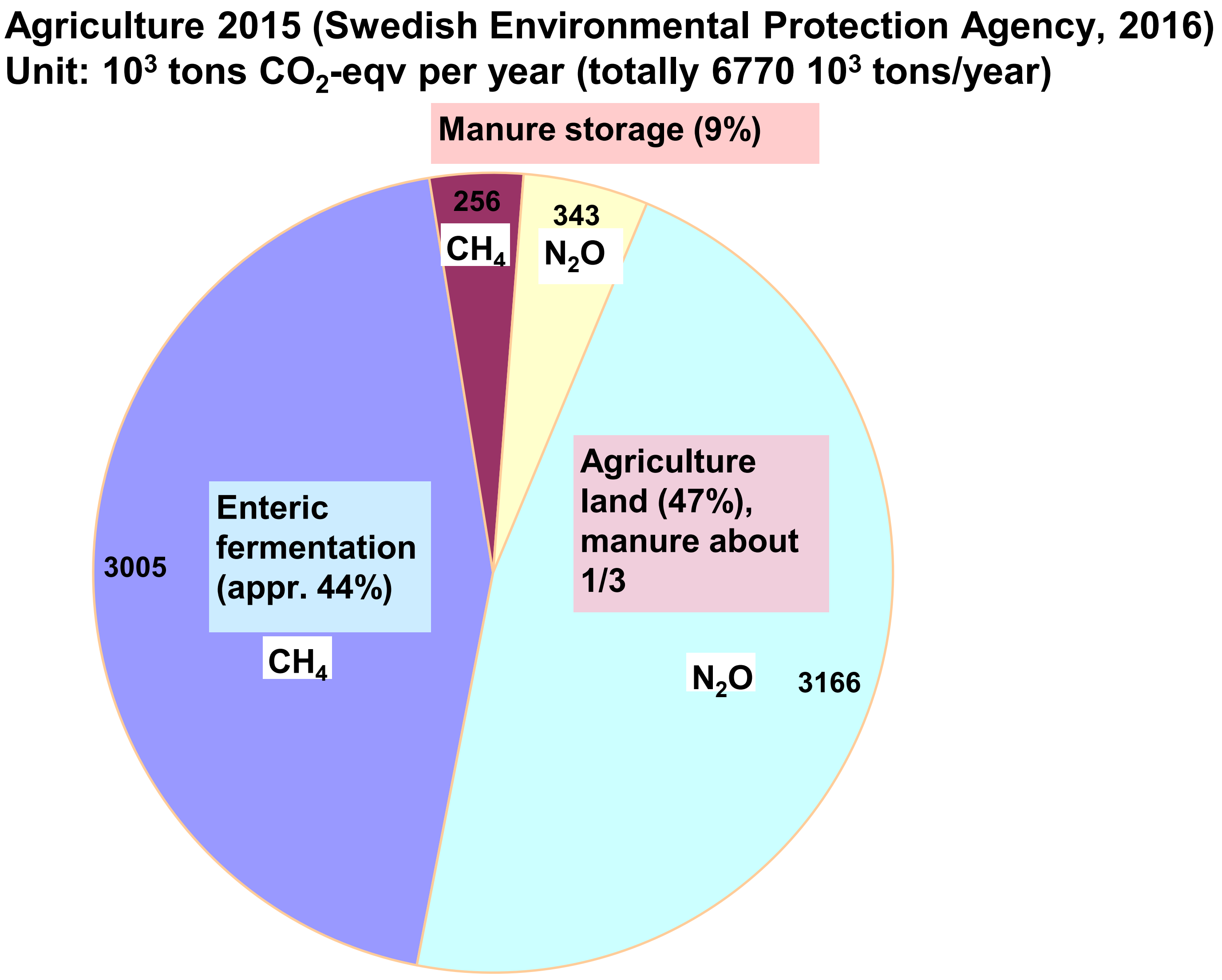
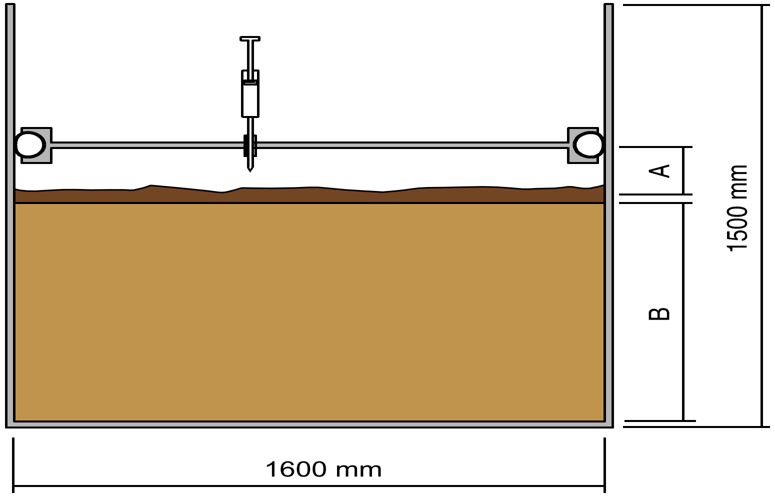
(www.ri.se)

Emissions from agriculture, nitrous oxide (N_2O) and methane (CH_4)



Pilot scale plant



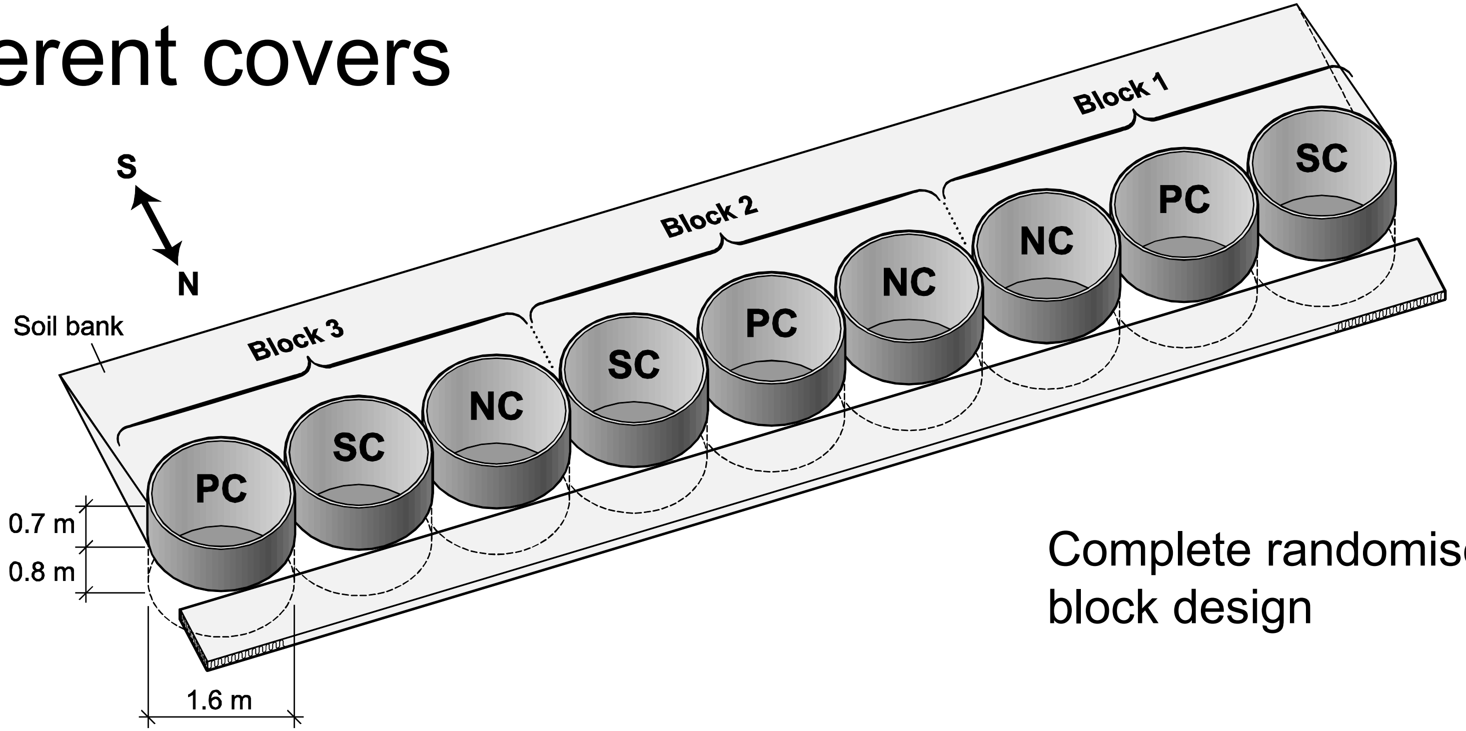
Closed chamber technique

1 year of cattle slurry,
1 year of pig slurry

Pig slurry, different covers

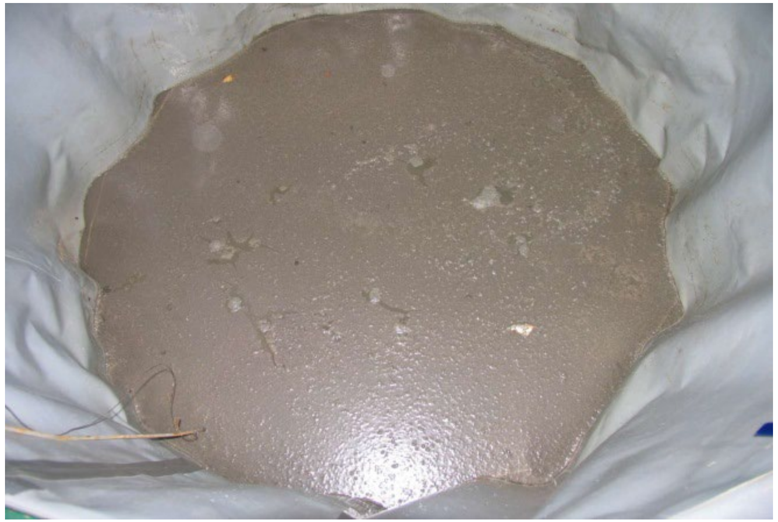
1 year study of:
- Cattle slurry
- Pig slurry

Simulation of filling and emptying as in full scale



Complete randomised block design

A) Slurry without crust



B) Straw cover

C) Plastic sheet cover

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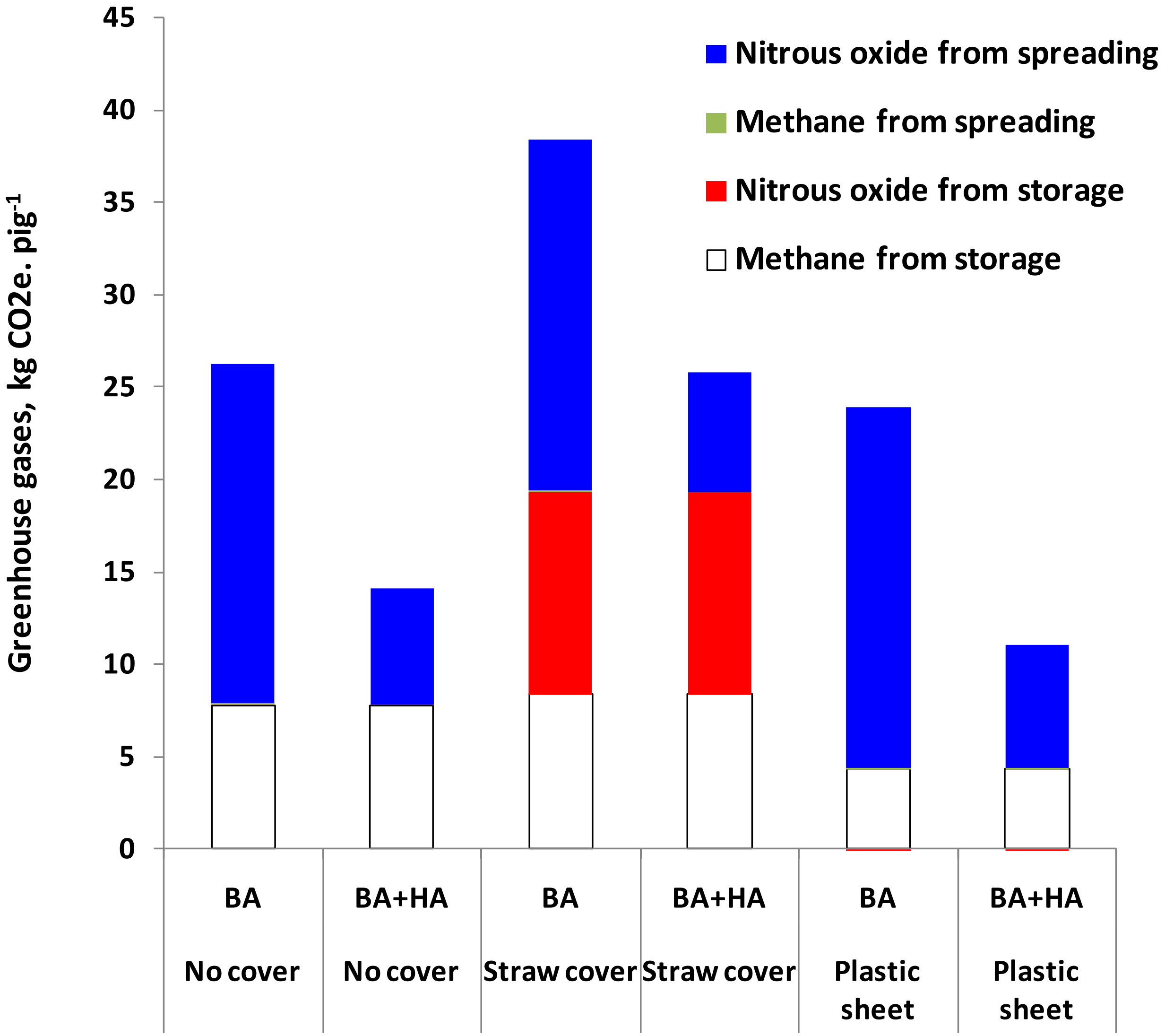
Storage and spreading of pig slurry: kg CO_{2eqv} per pig



Rodhe et al., 2012

Slurry: MCF*, %

*Methane conversion factor= [CH_4 (m^3) / (VS $_{IN\ storage}$ * B_0) (m_3)] * 100;
B_0: maximala CH_4 produktion for slurry per kg VS (m^3 / kg)

Cattle slurry	MCF (%)		
Tidsperiod	A) No crust	B) Straw cover	C) Plastic
Period 1 (okt–april, 210 dagar)	2,0	1,5	1,9
Period 2 (maj–okt, 157 dagar)	3,6[b]	3,8[b]	1,7[a]
Mean per year	2,7	2,5	1,8
Pig slurry	**MCF (%)**		
Tidsperiod	**A) No crust**	**B) Straw cover**	**C) Plastic**
Period 1 (okt–april, 213 dagar)	1,6	2,3	1,2
Period 2 (maj–okt, 152 dagar)	4,0	3,6	1,7
Mean per year	2,6	2,8	1,4
IPCC schablonvärden (≤ 10°C)	17	10	10

Rodhe et al., 2012
JTI-rapport 402
(sv.)

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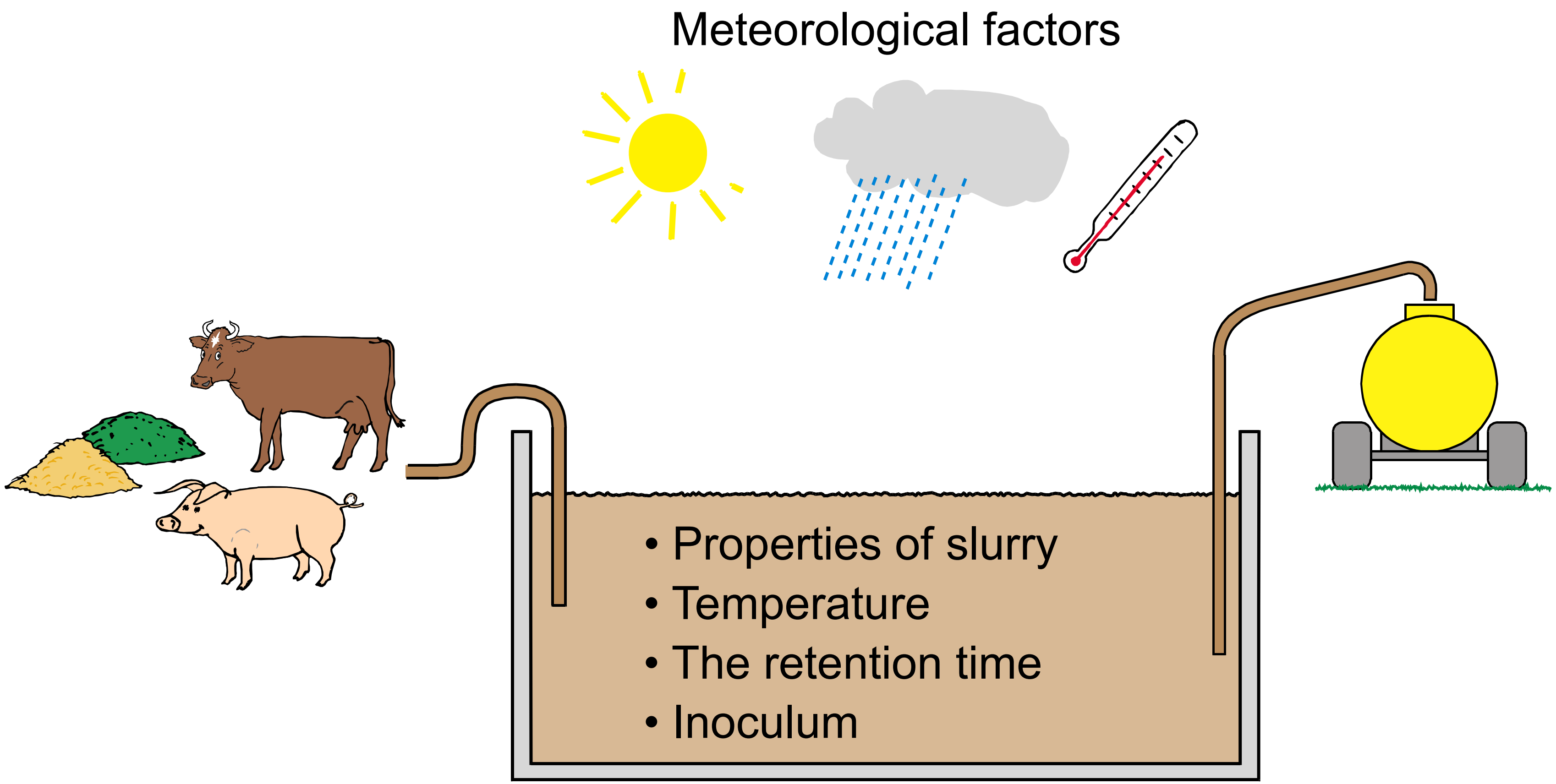
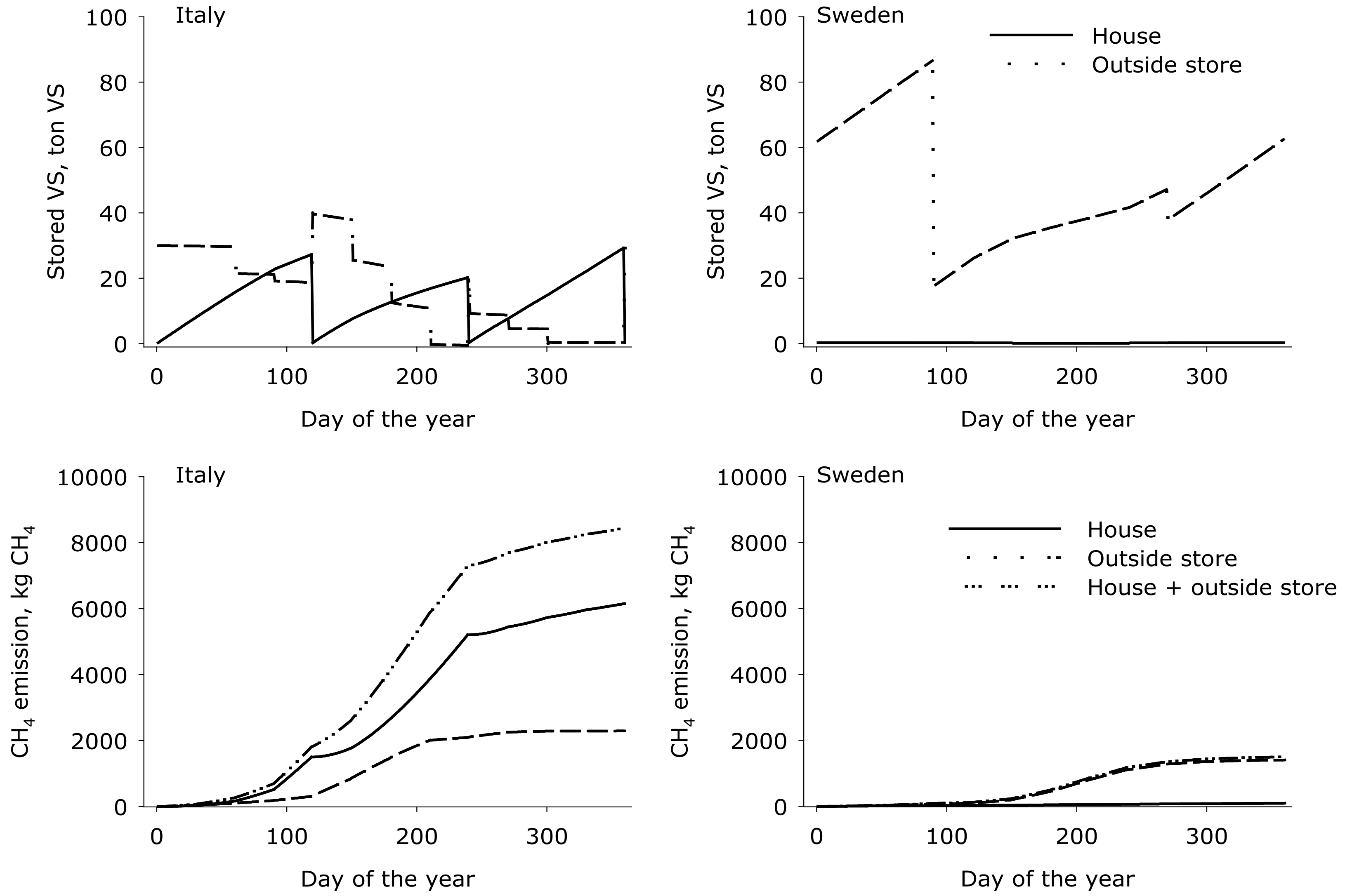
Methane (CH_4) from stored slurry: influencing factors



Methane emissions from cow barn + storage in Italy and Sweden, 50 milk cows

(Sommer, Olesen, Petersen, Weisbjerg, Valli, Rodhe & Béline, 2009)



Development of the model ongoing in EU-financed project **M4Models**

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Measures to reduce GHGs from storage

1. Reduce temperature during storage (CH_4, indirect N_2O)
2. Change properties of slurry in storage: reduce pH (CH_4, indirect N_2O)
3. Digest the manure to produce biogas to substitute fossile energy. (Optimize the biogas plant: high CH_4-production and minimize losses).

Ongoing: Study of efficient measures to reduce temperature in storage and thereby reduce CH_4 and NH_3 emissions

Placing a shadowing construction on a slurry tank

Shadowed slurry surface

Jordbruks verket

Europeiska jordbruksfonden för landsbygdsutveckling: Europa investerar i landsbygdsområden

Hushållningssällskapet Halland and RISE

Studied measures, temperature reduction

1. Shadowing the slurry compared to no shadow

2. Cover (plastic roof) *vs* no cover

3. Storage below ground level (partly) vs placed on ground

4. Relationship between depth and surface for the same volume (2 m vs 4 m deep, 1400 m^3) (used model: Rennie m.fl., 2018).

Jordbruks verket

Europeiska jordbruksfonden för landsbygdsutveckling: Europa investerar i landsbygdsområden

HUSHÅLLNINGSSÄLLSKAPET

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The results will be presented at

”Lantbrukets gödsel- och biogasdagar” i Falkenberg 24-25 oktober 2022.

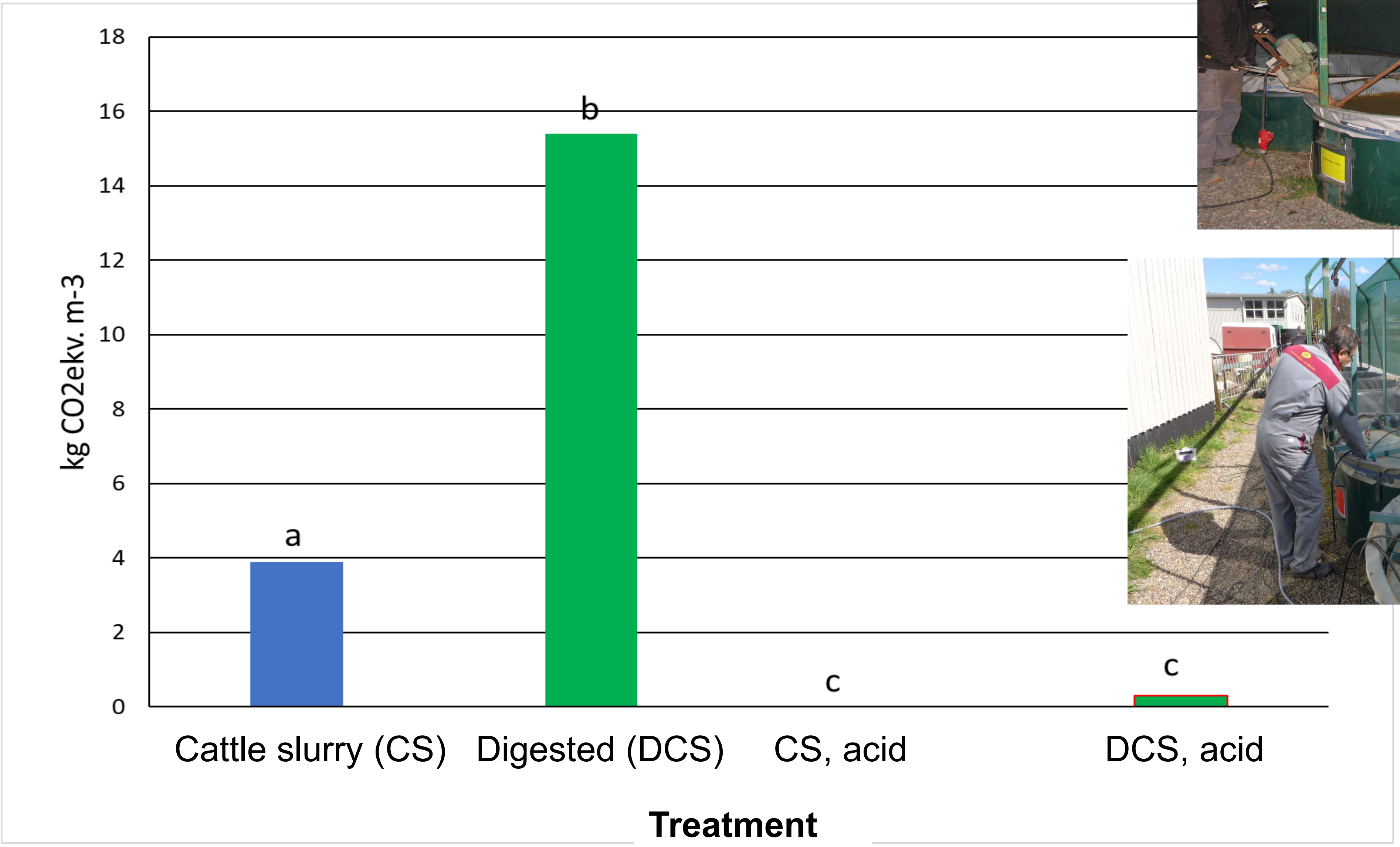
Acidification of slurry

- Addition of sulfur acid 2 to 6 litres per m^3

Addition in storage: pH 5.5

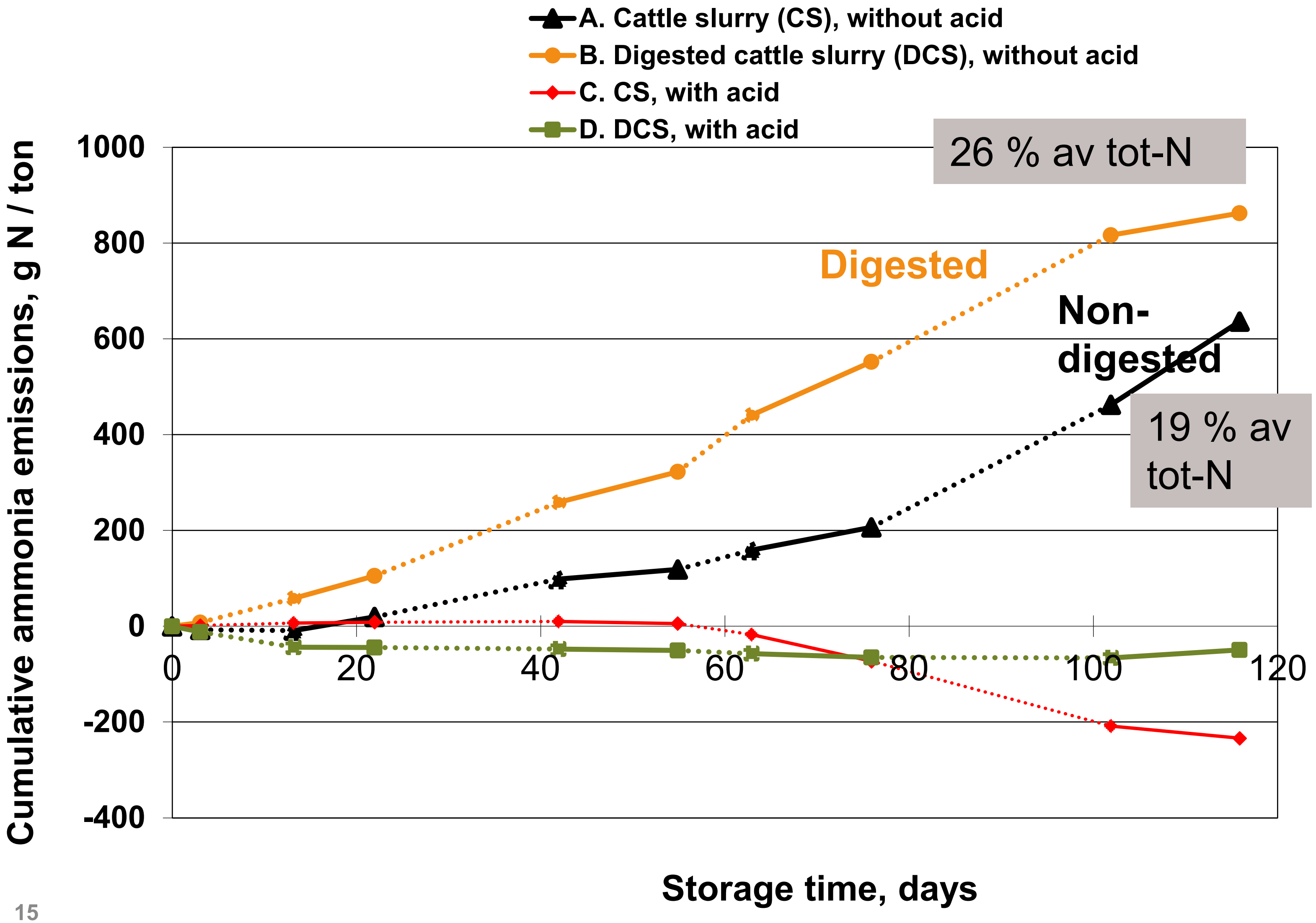
Addition during spreading: pH 6.4

Acidification (pH 5.5), effect on CH_4 emissions during storage (Rodhe m.fl., 2018)



Additionally, reduce ammonia emissions, and indirect N_2O

RISE-report 2019:51



Digestion of manure in Sweden (Energimyndigheten, 2020)

- Today (2020), there are about 54 biogas plants on farms in Sweden for digestion of mainly manure, but also additional organic residues or crops. In total, 282 biogas plants.
- Most of the manure (65%) is digested at central treatment plants.
- In total, 6% of manure produced from cattle, pig, sheep, goat, poultry are digested per year (1,200.000 tons manure are digested per year).
- In total, 3% of the produced biogas originate from manure.
- Retention time in reactor 15-30 days.
- Collection of residual biogas from storage rare (hard to get data). In Germany and Denmark very common and often mandory. Also, much longer retention times (>100 days in Germany).
- Storage of digestate identified as main source of GHGs on digestion plants (Liebetrau et al., 2013).
- Previous study shows about 3 times higher release of CH_4 from digested cattle slurry compared to undigested per m^3 stored during summer conditions (Rodhe et al., 2014; 2018).

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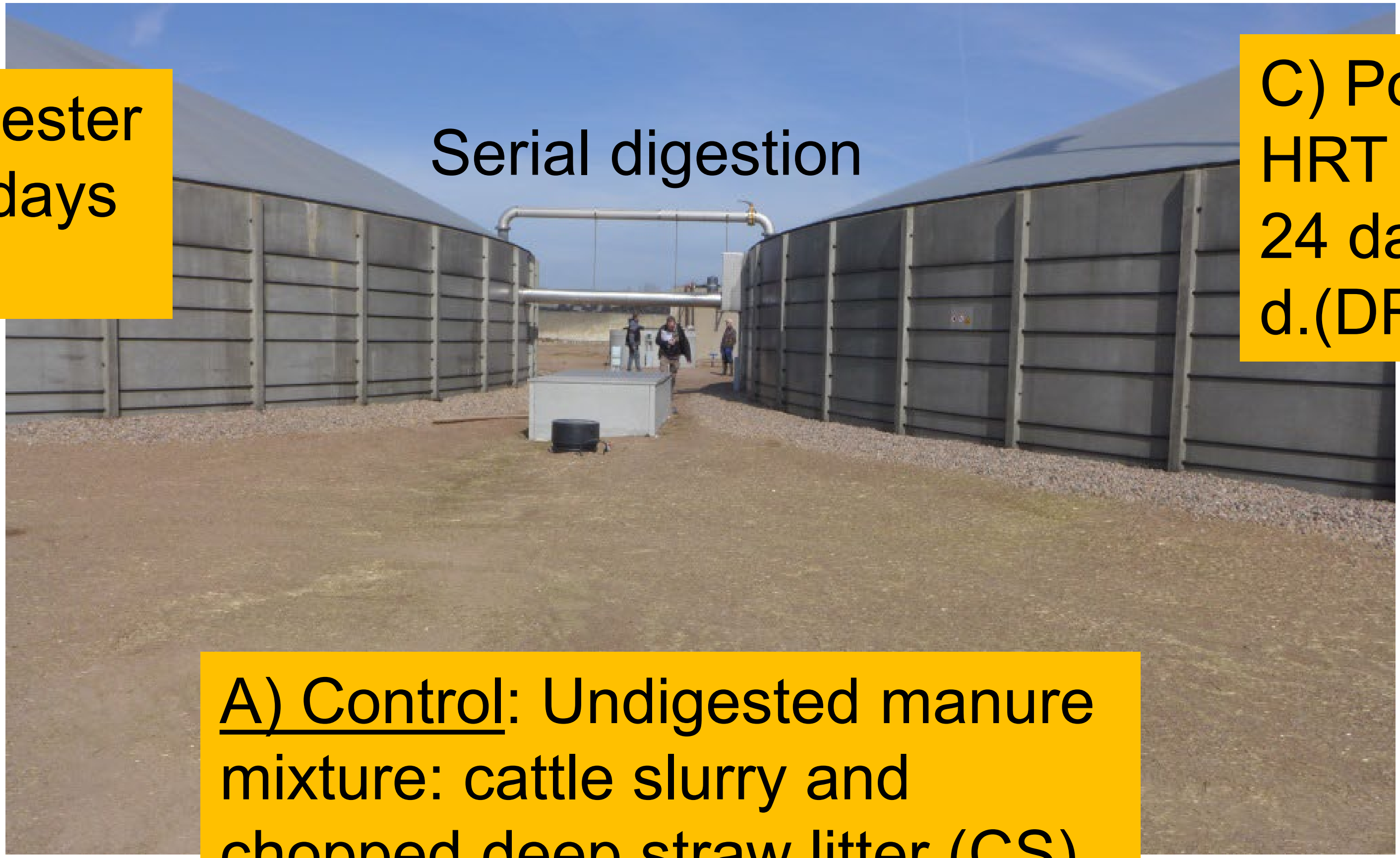
Retention time: 24 or 48 days?



Different retention times in digester, GWP_{100} storage

Type of slurry	**Methane** Mean, g CO_2eqv. original-m^{-3}	**Nitrous oxide** Mean, g CO_2eqv. original-m^{-3}	**Sum** Mean, g CO_2eqv. original-m^{-3}
A) Undigested (CS)	**11.0**^{c}	**4.8**^{a}	**15.7**^{b}
B) Digested DR1	**25.8**^{a}	**0.1**^{b}	**26.0**^{a}
C) Digested DR2	**18.4**^{b}	**0.0**^{b}	**18.4**^{b}

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Conclusions pilot scale storages, summer storage 5 months

- Two-step digestion during 48 days reduced methane emissions from storage with 30 percent compared with one-step digestion during 24 days.
- Methane emissions from digested slurry (one-step) were about 2.5 times higher, and two-step digested about 1.7 times higher compared with undigested slurry .
- Nitrous oxide was released from the undigested slurry with thick crust, started after about 65 days of storage.
- Methane emissions from storage were about 10% of produced methane from digester at one-step digestion, and about 6% at two-step digestion.
- GWP_{100} was in increasing scale: Undigested CS < Digested DR2 < Digested DR1.

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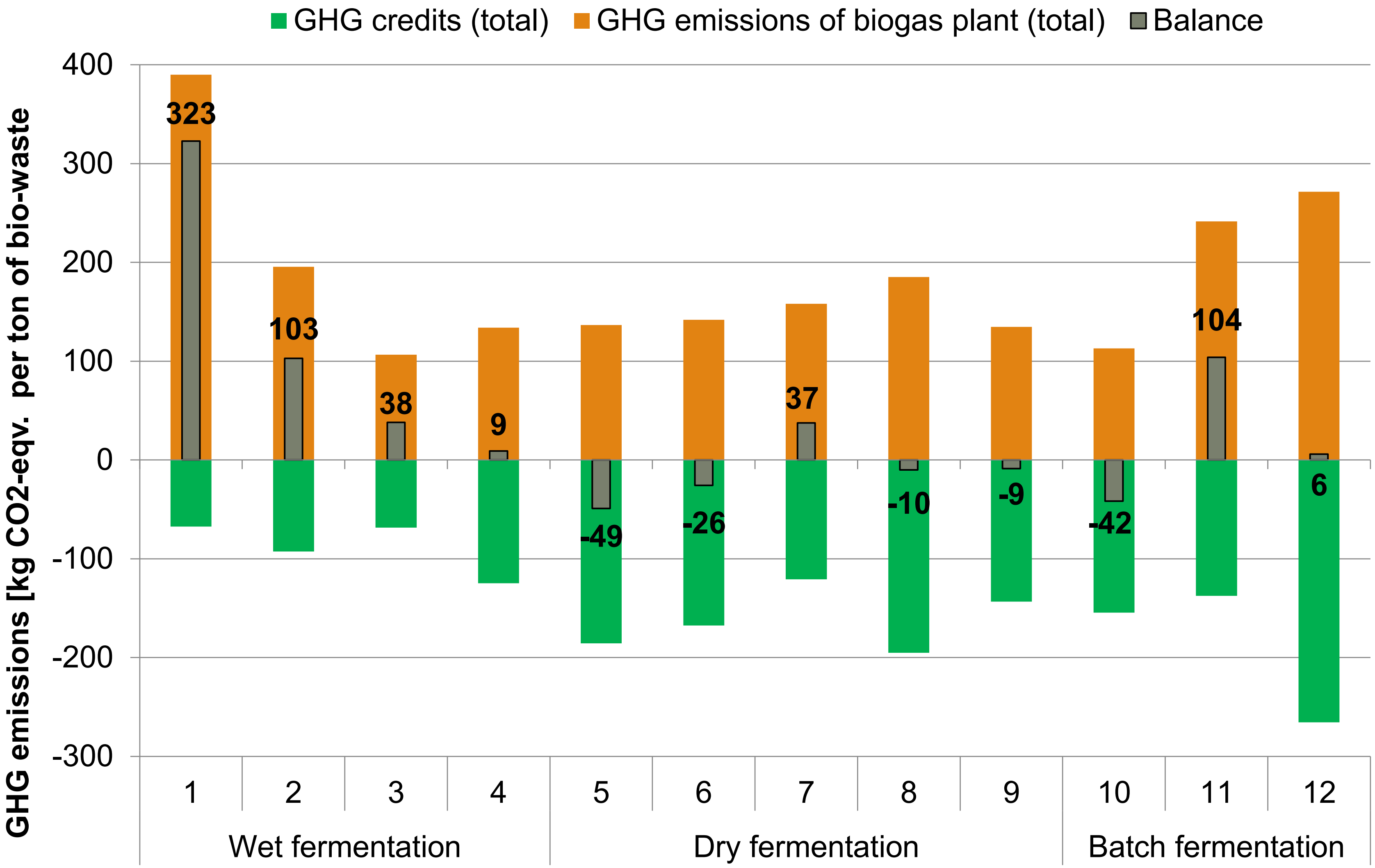
Biogas plants, balance CO_2-eqv. at digestion of bio-waste (12 plants)



Daniel-Gromke et al., 2015

Recommendations: Reducing Emissions from storage, DK (WRI, 2021)

1. Requirements of more frequent removal of manure from the barn (twice per day, like in Sweden)
2. Better national data – uncertainties in the emission estimates, test of operational slurry tanks missing
3. Place a moratorium funding new biogas manure digesters, not cost-efficient measure. Cease using agricultural crops.
4. Denmark should immediately and ambitiously test the various options for **acidification** at scale.

World Resources Institute (WRI), 2021. A pathway to carbon neutral agriculture in Denmark.

Recommendations to practice Sweden

- **Store cold! (means often small amounts in storage during summer).**
- **It is preferably with a synthetic cover to minimize the release of NH_3 and CH_4, as well as avoiding the risk of N_2O emissions that can arise with a straw cover.**
- **Ensuring proper digestion, e.g. through long retention time with post-digestion and/or collecting gases in gas-tight storage facilities.**
- **Cover of solid manure with plastic sheet reduce the N2O emissions significantly compared to straw cover.**
- **Acidifying slurry may be an alternative for Sweden to reduce NH_3 and CH_4.**
- **Small emissions of N_2O may outnumber large emissions of CH_4: Validate the whole handling chain to avoid counter-acting.**
- **Practice precision farming (application rate, timing, placement) to achieve low soluble content of N in soil in autumn.**
- **Avoid wet spots! Slurry injection conserve fertiliser N, with negligible NH_3 emissions but gives higher release of direct N_2O compared with band spreading.**

Praktiska råd nr 22, 2014, Greppa näringen, Jordbruksverket.

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THANK YOU

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References, selected

Daniel-Gromke J., Liebetrau J., Denysenko V. and Krebs C., 2015. Digestion of bio-waste – GHG emissions and mitigation potential. Energy, Sustainability and Society 5:3, DOI 10.11186/s13705-014-0032-6.

Liebetrau J., Reinelt T., Clemens J., Hafermann C., FrieheJ., Weilandd P., 2013. Analysis of greenhouse gas emissions from 10 biogas plants within the agricultural sector. Water Science Technology 67(6), 1370-9. doi: 10.2166/wst.2013.005.

Rodhe L., Ascue J. & Nordberg Å., 2009. Emissions of greenhouse gases (methane and nitrous oxide) from cattle slurry storage in Northern Europe, Earth and Environmental Science vol. 8, doi: 10.1088/1755-1315/8/1/012019.

Rodhe L.K.K., Abubaker J., Ascue J., Pell M. & Nordberg Å., 2012. Greenhouse gas emissions from pig slurry during storage and after field application in northern European conditions. Biosystems engineering 113, 379-394.

Rodhe L.K.K., Ascue J., Willén A., Vegerfors Persson B., Nordberg Å., 2014. Greenhouse gas emissions from storage and field application of anaerobically digested and non-digested cattle slurry. Agriculture, Ecosystems and Environment 199, 358-368, DOI: 10.1016/j.agee.2014.10.004.

Rodhe L., Alverbäck A., Ascue J., Edström M., Nordberg Å., Pizzul L, Tersmeden M., 2018. Åtgärder för att minimera växthusgasutsläpp från lager med rötad och orötad gödsel. RISE Rapport 2018:18. ISBN: 978-91-88695-53-6. RISE Research Institutes of Sweden AB.

Rodhe L., Ascue J., Tersmeden M., Pizzul L., 2019. Ammonia emissions from storage: non-digested and digested cattle slurry, with and without acid. RISE Rapport 2019:51. ISBN: ISBN 978-91-88907-79-0. Research Institutes of Sweden AB, Uppsala.

Sommer S.G., Olesen J.E., Petersen S.O., Weisbjerg M.R., Valli L., Rodhe L. & Beline F., 2009. Region-specific assessment of greenhouse gas mitigation with different manure management strategies in four agroecological zones. Global Change Biology 15(12), 2825-2837.

World Resources Institute (WRI), 2021. A pathway to carbon neutral agriculture in Denmark. WRI.org

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