Manure production and handling techniques on industrial-scale livestock farms in the Baltic Sea Region

Sindhöj Erik[1*], Kaasik Allan[2], Kuligowski Ksawery[3], Lazauskas Sigitas[4], Sipilä Ilkka[5], Tamm Kalvi[6], Vartukapteinis Kaspars[7], Rodhe Lena[1]

(1) JTI – Swedish Institute of Agricultural and Environmental Engineering, Uppsala, SE
(2) EMU – Estonian University of Live Sciences, Tartu, EE
(3) POMCERT – Pomeranian Center for Environmental Research & Technology, Gdynia, PL
(4) LRCAF – Lithuanian Research Center for Agriculture and Forestry, Kedainiai, LT
(5) MTT – Agrifood Research Finland, Jokioinen, FI
(6) ERIA – Estonian Research Institute of Agriculture, Saku, EE
(7) LLU – Latvia University of Agriculture, Jelgava, LV
*Corresponding author: erik.sindhoj@jti.se

Abstract

Manure handling techniques were studied on 31 large-scale livestock farms in the Baltic Sea Region using surveys and personal interviews. At least two dairy, two pig and one poultry farms in 6 countries were included in the study. Livestock density was lowest for dairy farms (around 1 LU ha^{-1}), but five-fold greater for pig and poultry farms. Average manure production per farm was greatest for poultry farms followed by pig farms and then dairy farms. Manure on pig farms was handled as slurry, while poultry manure was handled mainly in solid form. On dairy farms 65% of total manure was handled as slurry and the remaining as solid. Manure processing was found on 22% of the farms most often as anaerobic digestion but two times as mechanical separation. Slurry was most often stored in tanks made of concrete panels and more than half of the storages were covered, most commonly with natural crusts. Mean slurry storage capacity was 7 months for dairy farms and almost 9.5 for pig farms (14 months including 2 farms with large lagoon storage systems). Slurry was mainly band-spread (84%) with application rates of 20 to 30 t ha^{-1}. Farmers identified a range of bottlenecks for utilizing nutrients in manure including: 1) cost and economic factors, 2) technological limitations, 3) lack of knowledge and 4) regulations or lack of support mechanisms.

Introduction

The Baltic Sea Region (BSR) is an area of intensive agricultural production, and nutrient losses from animal production are responsible for a significant amount of the nutrient load on the Baltic Sea (HELCOM 2011). The project Baltic Manure provides a forum for stockholders in the BSR to work towards improving nutrient recycling and reduce the environmental load from animal production to the Baltic Sea. This study is part of the Baltic Manure Project to give a review of existing manure handling techniques used on large-scale dairy, pig and poultry farms in the BSR. In-depth studies were carried out with the aim of providing an overview of techniques currently used along the entire manure handling chain, from animal feeding practices to field application. The specific methods and techniques used for manure handling influence the physical and chemical properties of manure, including how well nutrients are utilised in plant production. An additional aim was to identify bottlenecks and barriers on farms to the use of manure as a fertiliser resource.

Material and Methods

About five case-study farms were chosen in each of six BSR countries: Estonia, Finland, Latvia, Lithuania, Poland and Sweden. At least two dairy farms, two pig farms and one poultry farm were included per country. The minimum size for the case study farms was set at the number of livestock units (LU) regulated by EU Directive 2010/75/EU (IED) on industrial emissions for pig and poultry farms, or the equivalent LU value for dairy farms. Coefficients for calculating LU for various livestock and animal types were used according to Eurostat (www.epp.eurostat.ec.europa.eu). The Eurostat LU coefficients used were differed from coefficients used by some countries in the BSR which could affect interpretations when comparing with other studies. Farm surveys were conducted during 2011 and 2012 through personal interviews using a questionnaire created for each of the three livestock types.

Results and discussions

Manure production

The number of livestock on the case-study farms ranged from about 400 to over 30 000 LU. In general the mean and median number of LU per farm was relatively similar for diary (518 mean and 509 median) and poultry farms (6128 mean and 5676 median), however there was a large difference between mean (5514) and median (2938) sizes for the pig farms, largely due to one pig farm with 31 260 LU. The average LU density was lowest for dairy farms at about 1 LU ha^{-1}, 4.9 LU ha^{-1} for pig farms and 5.5 LU ha^{-1} for poultry farms, although these averages excluded several poultry and pig farms which operated without any land and exported all manure to other farms. When livestock density increased over 1.7, exporting a portion of their manure off-farm became common mainly on pig and poultry farms and 40% of the total manure production on all farms in this study was exported off-farm.

Manure on pig farms was handled exclusively as slurry except one farm which predominately had slurry handling but kept their breeding sows in deep-litter pens and therefore generated a small amount of solid manure. Poultry manure was mainly in solid form although one farm had slurry handling for caged laying hens. For the dairy farms, 62% of the total amount of manure was handled as slurry and the remaining 38% as solid manure. Most dairy farms had their milking cows on slurry handling and in some cases recruitment and young animals on solid manure handling. Mean annual manure production per farm was lowest for dairy farms (12 350 ± 6050 t yr^{-1}) followed by pigs (27 750 ± 23 500 t yr^{-1}) and then poultry (46 800 ± 72 500 t yr^{-1}) farms. However, the mean annual manure production per LU was greatest on dairy farms (26 ± 9.1 t LU^{-1} yr^{-1}) followed by pigs (7.9 ± 4.4 t LU^{-1} yr^{-1}) and poultry (5.8 ± 7.8 t LU^{-1} yr^{-1}). Most of the variation in manure production per LU for poultry was related to one farm with very high manure production rates. No clear trends in manure production for pigs and cattle were seen between countries, and there was slight increase in manure production with increasing milk production on dairy farms although not significant.

Housing

For slurry, the dominant practices were at minimum daily manure removal with scrapers in primary channels, gravity flow in cross-channels to temporary storage in pumping pits. For the solid manure, mobile manure removal technology was commonly used but removal frequency was generally not given.

On cattle farms, water addition reported were between 0.6 and 7.9% of the total volume of slurry produced, which is probably an underestimate since not all sources were included. On cattle farms, cleaning water for milking equipment and milk tanks, and rinsing water from milking parlour and waiting areas were the main sources for dilution but also water from showers and in some cases toilets. Water additions on pig farms were reported to be 3.3 to 12.7% of the produced slurry, and came mainly from cleaning the houses after each production batch; however drinking water spillage is another source of additions that is harder to estimate.

Straw was the most commonly used bedding material used on dairy farms followed by wood shavings and peat. Pig farms in most cases (8 of 12) did not use any bedding material and the four farms that did generally used combinations of straw and wood shavings. The three poultry farms using cage systems did not use bedding, while broiler production systems used peat and wood shavings.

Processing

Manure processing was found on 7 of the 31 farms as either anaerobic digestion or mechanical separation. Anaerobic digestion for biogas production was found on three pig farms and two dairy farms. Mechanical separation of slurry was found on one dairy farm and one pig farm.

Storage

Slurry was most commonly stored in tanks made of concrete panels. About 60% of the slurry storages were covered and most of these were with natural crusts. Figure 1 presents frequency of farms using different forms of storage including covers. The mean storage capacity for slurry, including satellite

storage, was 7 months for dairy farms and 13.8 months for pig farms although two pig farms had lagoon storage systems with capacities dimensioned for when the farms had greater production levels than today. Not including these two farms average storage capacity for pig farms was about 9.5 months. Figure 1 presents frequency of farms using different forms of storage including covers.

Solid manure was most often stored on concrete pads, but also in field heaps. The solid manure was mainly without a cover, although on two farms poultry manure was either covered with peat or straw.

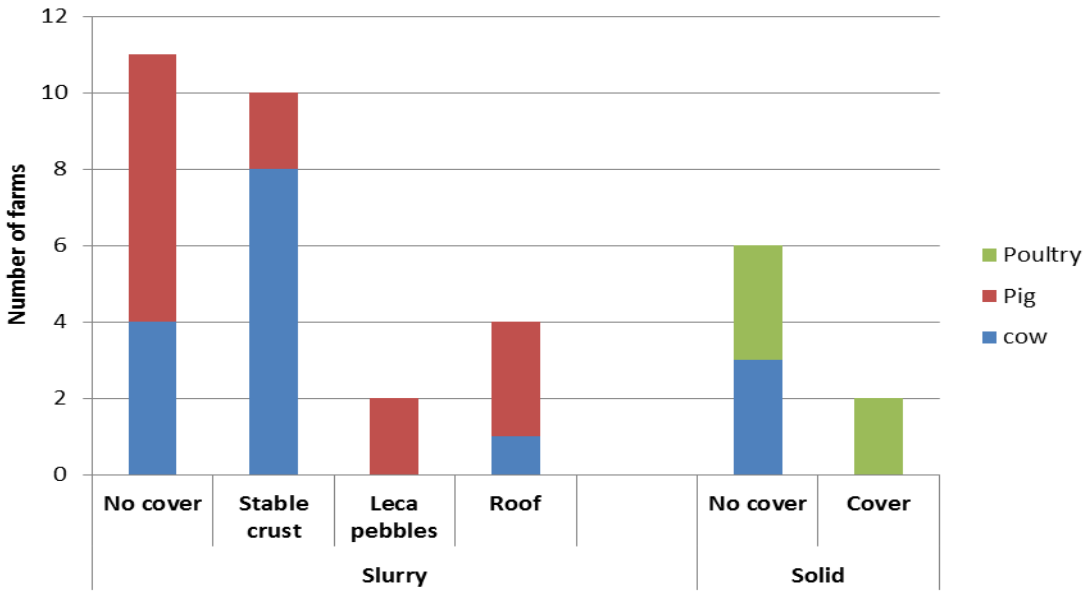

Figure 1. Frequency of farms using different forms of storage covers for manure as slurry or solid manure.

Spreading

All manure was used as fertilisers when information was provided, however the detailed use of manure exported off-farm was largely unknown. The slurry was mainly band-spread (84%) on grassland (cattle farms) or before sowing of a cereal crop in spring or early autumn (pig and poultry farms). Three farms used umbilical hose systems for serving the spreader with slurry, which accounted for 42% of the total amount of slurry applied with band spreading techniques. Application rates of 20 to 30 tonnes ha^{-1} dominated, but rates as high as 80 tonnes ha^{-1} were reported. Only about 7% of the slurry was spread with injectors, either with shallow disc tines in grassland (about 0.05 m working depth) or with cultivator tines in open soil with working depth of 0.15 m before sowing a crop, often maize. Broadcast spreading was only used for 8.3% of the slurry. On open soil, the manure was incorporated directly after spreading on some farms, while on other farms incorporation occurred some hours after spreading or within a day, but in many cases no information was provided.

Poultry manure was applied at rates of 2.5 to 10 tonnes ha^{-1} but with low spreading accuracy, as existing spreaders cannot cope with such low doses.

When livestock density was greater than 2 LU ha^{-1}, some or all of the manure was exported off-farm (Figure 2). In total for all farms studied, 13% of slurry produced and 86% of solid manure was exported off-farm. Information concerning the use of manure exported off-farm was most often not available.

Bottlenecks and barriers for using fertilizer recourses in manure

Farmers identified a range of barriers that made it difficult to fully utilize the nutrient resource potential in manure. These were classified into four categories: 1) costs and economic factors, 2) technological limitations, 3) lack of knowledge of solutions, 4) regulations or lack of incentives for adopting best available technologies. Specific problems often cited by farmers were inadequate storage

capacity, high cost for injection techniques, logistical costs associated with transporting manure to the fields, odour nuisance for neighbours, and soil compaction during spreading were the most often cited bottlenecks for utilizing manure nutrient resources in crop production.

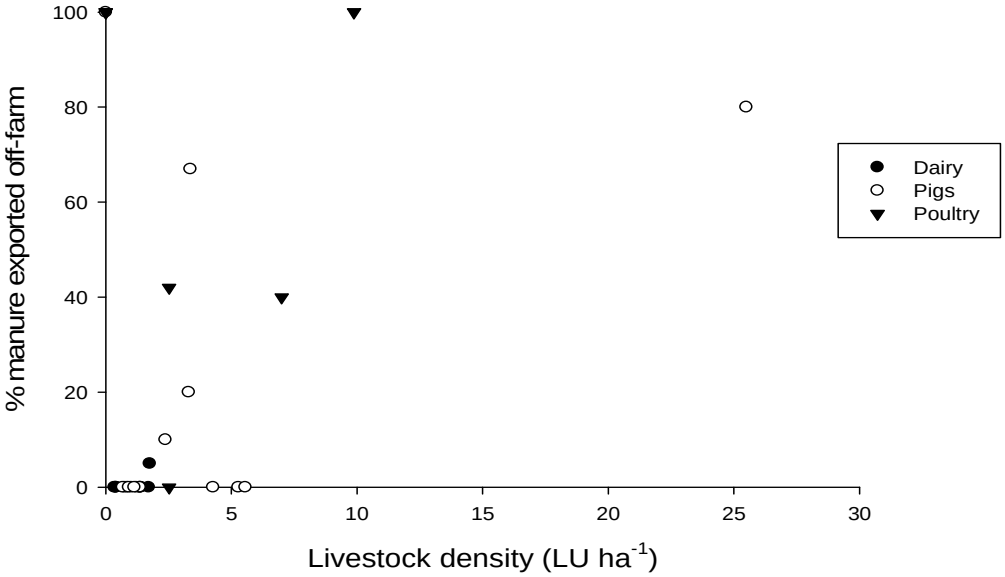

Figure 2. Percentage of manure exported off farm as a function of farm-level livestock density. The three farms (2 poultry and 1 pig) that did not own any land and exported 100% of their manure are shown having a livestock density of 0, when actually they had a value of infinity.

Conclusion and perspectives

The large differences in manure production rates between farms of similar livestock types indicates that manure default values are not adequate for making manure management decisions on the farm-level. The large differences in manure production per LU for specific livestock types could possibly be explained by water additions to manure during various stages of the manure handling chain. In general, details of manure handling after storage were the least well-described part during surveys of the manure handling chains, and this was most apparent for manure exported off-farm. Examples of environmentally friendly technology such as slurry store covers, pumping for transport, injection techniques, umbilical hose distribution in field, anaerobic digestion and mechanical separation were found in all countries, showing both a demand from farmers and the capacity of the market to supply these technologies. There is a need to increase storage capacity to allow spreading manure when most needed by crops, and there is a need to minimize ammonia emissions during storage with for example covers and after spreading for example with injection techniques. Costs and lack of economic incentives for investing in environmentally friendly manure handling technology were the main barriers to overcoming farm level bottlenecks that limit manure nutrient utilization on the farm-level.

References

HELCOM. 2011. The Fifth Baltic Sea Pollution Load Compilation (PLC-5). Balt. Sea Environ. Proc. No. 128.

Sindhöj, E., L. Rodhe (Eds.). 2013. Manure handling techniques on case-study farms in the Baltic Sea Region. Knowledge Report from WP3 of the Baltic Manure Project. www/balticmanure/eu.

Acknowledgments

This study was performed within the Baltic Manure Project which is a Flagship Project in the Action Plan of the EU Strategy for the Baltic Sea Region (BSR) and is co-funded by the Baltic Sea Region Programme of the European Union.