Handling of manure in deep-litter pig houses.

Manutention des déjections dans les bâtiments porcins sur litière biomaîtrisée.

Esa Klemola and Sirkka Malkki
TTS-Institute, Work Efficiency Institute.
P.O. Box 13. FIN-05201. Rajamaki. FINLAND
E-mail : Smalkki@ns.tts.fi

Abstract

Pigs are kept on a thick layer of sawdust bedding in deep-litter pig houses. The manure is mechanically mixed with the sawdust every week so that it starts composting. Furthermore, the composting process produces heat which then evaporates extra moisture. Pig houses are emptied once a year; the precomposted manure is heaped in a field to after-ripen. New litter is spread on the floor and no separate storehouse for faeces and urine is needed, since the litter bedding acts as a repository.

A well-functioning deep-litter system entails approximately the same amount of work as does the removal of manure and cleaning of pens in liquid-manure pig houses particularly when the litter is mixed with a cultivator or a screw-mixer. Moving pigs and opening gates take nearly half of the actual working time. Deep-litter bedding is relatively quick to muck out with a loader.

Unlike the liquid-manure method, where the workload is evenly distributed over the days of the week and the handling of manure is relatively simple, the mixing of the litter requires peaks of work in the week. Despite regular mixing, the deep-litter bedding sometimes fails to compost; this happens especially under subzero temperatures and if there are too many pigs in relation to the floor area, or if ventilation and extra heating are inadequate. Replacing the litter partly or completely furthers the composting process, but also considerably increases the workload and litter costs.

Some pig farmers have found the tending of the deep-litter bedding so laborious and unpleasant that they have replaced it with liquid-manure or solid-manure systems. In order to achieve the composting process of deep-litter bedding, the number of pigs should often be decreased, which would naturally reduce the profitability of each pig house. The deep-litter bedding system has worked well for sows, for which deep-litter housing is still being built in Finland.

Résumé

En bâtiment sur litière profonde, les porcs sont placés sur une couche épaisse de litière de sciure. Les déjections sont mélangées à la sciure chaque semaine ce qui permet le démarrage du processus de compostage. Ce même processus dégage de la chaleur qui ainsi évapore l'humidité en excès. Les bâtiments sont vidés une fois l'an. Le fumier précomposté est alors placé en tas en bout de champ. Une nouvelle litière est épandue sur le revêtement.

Un bon fonctionnement de ce système sur litière nécessite la même quantité de travail que l'évacuation des déjections et le nettoyage des salles en système lisier, notamment lorsque la litière est mélangée à l'aide d'un cultivateur.

Cependant, contrairement au système lisier pour lequel l'investissement en travail est continu au cours de la journée, le mélange de la litière nécessite des pics de travail au cours de la semaine. Au delà du mélange régulier des déjections et de la sciure, la litière ne composte pas. Cela se produit lorsque les températures sont basses et le nombre d'animaux trop élevé par rapport à la surface au sol ; ou bien si la ventilation et le chauffage ne sont pas bien adaptés.

Quelques éleveurs de porcs ont trouvé ce système de gestion trop laborieux et désagréable et sont alors revenus au système de gestion avec lisier ou avec des systèmes sur paille. Afin de permettre le déroulement du compostage, le nombre d'animaux par unité surface doit être réduit, ce qui diminue d'autant la rentabilité des bâtiments. Ce système de litière biomaîtrisée est bien adapté dans les bâtiments avec truies qui sont encore construits en Finlande.

1. Introduction

Deep-litter pig houses rapidly became popular in Finland in the mid-1990s. Today they are being used in approximately 150 farms which mainly specialise in finishing pigs and sows. Low construction costs and the possibility to put the pig house quickly into productive use increased the popularity of this method. The deep-litter method was also considered safe for both animals and the environment (Klemola 1998)

In deep-litter pig houses the pigs are kept in large pens (usually over 50 pigs per pen) on litter bedding 50–60 centimetres deep. Manure is mixed with the litter which then starts composting. The composting process produces heat which, together with efficient ventilation and heating, evaporates extra moisture. The volume of manure also reduces considerably.

Sawdust is the most common sort of litter used in deep-litter pig houses (Ketola 1994, Kolhi 1995, Laine 1997), and it is replaced once a year. The precomposted manure is heaped in fields to ferment further and later to be spread. No separate storehouse for faeces and urine is needed, since the litter bedding acts as a repository (Anon. 1992). In the future, however, storehouses for manure may

become obligatory, when new directions for the handling of manure become effective in Finland.

The key issue of the deep-litter method is the functionality of the compost, which has an impact not only on the pigs' welfare but also on the amount of work required and production costs. Under the weight of the pigs the sawdust becomes so packed that the compost fails to receive enough oxygen, which then inhibits its composting. Excessive moisture fills the air pores in the sawdust and the litter becomes saturated. These problems occur particularly during subzero temperatures when the evaporation of moisture is inadequate.

The removal of moisture from the litter and the indoor atmosphere of the pig houses requires more efficient ventilation and additional heating than in conventional pig houses (Suomi 1995, Pyykkönen 1996). Furthermore, the litter area for each pig has to be adequate. According to present building recommendations and the energy calculations made by Puumala and Pyykkönen (1997), the adequate area per pig in deep-litter houses is 1.5 m^2, whereas in pig houses with liquid-manure systems the corresponding area is 0.8 m^2 (Kotkansaari and Väänänen 1996).

In order to create optimum conditions for the composting of the litter, the bedding has to be mixed every week with a cultivator, a tractor rotavator, or special machinery. During the mixing, wet sawdust is often moved from one place to another to equalise the moisture content of the bedding. When necessary, wet sawdust can also be replaced with fresh, dry litter in places where the pigs usually defecate.

Knowledge on the impact of the deep-litter bedding on the workload in pig houses is rather contradictory. Approximately only 20 per cent of those who answered the questionnaire compiled by Kolhi (1995) thought that the use of deep-litter bedding increased their workload. Furthermore, the increased workload was not considered a serious disadvantage. The study conducted by Pyykkönen (1994) also gave a fairly optimistic outlook of the amount of work required by the deep-litter method. In a number of articles, however, the method was criticised for the excessive workload it demanded; the mixing of the deep-litter bedding was also regarded as laborious and unpleasant. In Laine's study (1997), 27 per cent of the respondents considered the deep-litter method easier than the conventional one, whereas 50 per cent thought it more laborious, and the rest were unable to estimate the workload or considered it equal in both methods.

The TTS-Institute conducted a work study on the labour consumption required by the mixing of deep-litter bedding in pig houses and other influencing factors. The quality of the work done by machines in the mixing of the litter was also studied as well as the impact of different types of buildings on the tending work.

2. Materials and methods

During 1996–97, altogether fourteen work studies were carried out in pig houses to calculate the working hours required by cultivators, screw-mixers, tractor loader, and loading shovel in the mixing of litter. The most commonly used machines in the mixing of litter are the cultivator and tractor loader. The screw-mixer was developed specifically for the mixing of litter (Ketola 1994, Kolhi 1995, Jussila and Penttilä 1996, Penttilä 1995). The time used in replacing litter with a frontloader was also defined.

The norms for each machine used in the mixing and replacing were based on the work study. These were calculated on the assumption that there are ten pens of fifty pigs each and the litter area is 750 m^2 (=1.5 m^2 per pig). The norm represents labour consumption or output. It includes the various phases of work (e.g. preparing for the work and actual work), the disrupting factors in the work, the recovery period which depends on how strenuous the work was, and the amount of working time as a proportion of the regular daily work routine (Anon. 1988).

3. Results and discussion

According to the work study, mixing the litter with a cultivator or with a screw-mixer took more or less the same amount of time (Table 1). With a cultivator, a clearly longer period of time was spent on turning and reversing the machine in the pen. If it were possible to have driven through the pig house, there would be less unnecessary driving. A screw-mixer worked better than a cultivator, since it could dig deeper for clean sawdust. Mixing was considerably slower with various loaders and particularly a loading shovel than with a cultivator or screw-mixer. However, loaders could be used to move wet litter from one place to another and this way equalise the moisture content of the bedding.

The size of a pig house or compartment contributed to the labour consumption. For a pig house which was divided into several small compartments, the time used in mixing the litter could double compared with typical deep-litter pig houses. In the latter case, the pens were arranged in a row so that the whole area could be mixed in two phases.

Pig house	Labour consumption min./100m²	Work time min./500 pigs
Mixing the litter, one person		
. with a cultivator	8.2	62
. with a screw-mixer	10.1	76
. with a tractor loader	18.4	138
. with a loading shovel	39.3	295
Opening gates and moving pigs, two persons.	15.6	117
Preparations (manual), two persons	2.2	17

Table 1
The norms of mixing the litter in pig houses (500 pigs, 10 pens, litter area 750 m^2) and the working time of two people in a pig house for 500 pigs.

During the mixing of litter, nearly half of the working time was spent opening gates and moving the pigs. This could be done more quickly, if the gates were lighter and easier to handle. Larger pens failed to make the work any faster, since moving the pigs in a large pen was more laborious. In addition, the more pigs there are, the more the rate of their growth varies, and they have to be sold in several lots. Even though tail-biting and other aggressive forms of behaviour are rare in deep-litter pig houses, they may become a problem in larger pens (Penttilä 1995, Pyykkönen 1995).

Mixing litter in a pig house for 500 pigs took 3.3–7.2 hours, depending on the machinery used. Correspondingly, the annual working time per pig was approximately 20 minutes, when the litter was mixed once a week with a cultivator or screw-mixer. Mixing the litter with a loading shovel took approximately 40 minutes per pig, if there were two persons opening the gates and one person doing the mixing. If the whole procedure were regarded as a task for two persons, as it usually was, the amount of time used would be somewhat higher (Table 2).

	Annual labour consumption		
Mixing machine	min./pig	min./pig space	min./pig space (2 pers.)
Cultivator	6.2	19	25
Screw-mixer	6.7	20	27
Tractor loader	8.7	26	39
Loading shovel	13.7	41	69

Table 2
Labour consumption when litter was mixed once a week and there were three lots of pigs per year

The sawdust bedding was replaced completely after three lots. If the bedding was very wet, it had to be replaced more often. According to the results of the study, the various working phases in the replacement of the litter were relatively easy and quick to accomplish. Loading the litter manure was fast. However, cleaning the edges manually somewhat increased the labour consumption. Replacing the litter took only 3.6 minutes per pig, if a quarter of the litter was replaced twice before the complete replacement. This way replacing the litter took only 1.2 minutes per pig, when the litter was replaced after three lots (Table 3).

	Time according to norm		
Mixing machine	min./100m²	min./pig space	min./pig
Removal of old litter and cleaning of the pen	102	1.5	0.51

Taking new litter in	69	1.0	0.34
Partial replacement of litter (25%)	34	1.0	0.34

Table 3
Labour consumption when the litter was changed with a fronloader. Three lots per year per pig space.

Unlike liquid manure, litter manure usually had to be handled twice: first it was heaped in the field and only later spread where needed, whereas liquid manure was taken straight from the storage to the field. The amount of manure was considerably larger in the liquid-manure method, since it contained a lot of liquid, but the workload of driving and spreading the manure was more or less the same for both methods.

When all the work in the pig house and the driving of the manure were added, the overall labour consumption in the deep-litter pig house amounted to 28 minutes per pig, if the litter was mixed with a cultivator or screw-mixer, and 37 minutes per pig when using a loading shovel. The size of the pig house and the mixing and replacing frequency was assumed to be the same as in the previous calculations. In the liquid-manure pig house the overall labour consumption was 31 minutes per pig as calculated according to agricultural norms (Anon. 1988).

For the liquid-manure method, the removal of manure occurred efficiently and the workload was evenly distributed, except for the spreading of manure on the field. In contrast, the mixing of the deep-litter bedding caused weekly work peaks. The workload was further increased as a precaution against failure to compost. The mixing of the litter entailed laborious working phases under poor conditions, which was why tending the deep-litter pig house was often considered unpleasant and more laborious than it actually was.

The deep-litter method has been considered safe for both animals and the environment. Nitrogen losses may be greater than with the liquid-manure method, since lots of nitrogen evaporates as ammonia and nitrous oxide (N_2O) from the compost (Groenstein ref. Kaufmann et al. 1997). Nutrients are also easily washed away, if insufficiently composted manure is piled uncovered in the field, as is often done today.

4. Conclusion

The tending of a functional deep-litter bedding required more or less the same amount of work as the removal of liquid-manure and the cleaning of pens in conventional pig houses. In practice, however, the mixing intervals in the deep-litter pig houses had to be shortened or wet sawdust replaced, if the composting process failed to occur. This increased both the workload and litter costs considerably.

In the deep-litter method, the litter area had to be 1.5 m^2 per pig so that extra moisture could be evaporated by the heat produced by the composting process. Ventilation and additional heating also had to be more efficient than in conventional pig houses. The function of the compost could be improved by mixing the litter regularly. However, problems caused by the design of the pig house or due to too many pigs could not be solved by mixing deep litter.

Farmers often regarded the tending of the deep-litter bedding as laborious and unpleasant, particularly if handling the gates and moving the pigs were not considered when designing and building the pig house. Problems with the function and handling of deep-litter bedding have decreased the popularity of this method to the extent that some farmers have already replaced the deep-litter with a conventional pig house using liquid manure system. For sows, however, the deep-litter bedding has worked due to correct number of pigs and regular mixing.

5. References

ANON. 1988. Maatalouden työnormit. Työtehoseuran maatalous- ja rakennusosaston monisteita 2/1988. 157 p.

ANON. 1992. Karjasuojien vesiensuojelua koskeva valvontaohje 61 ja siihen 3.4.1992 tehdyt muutokset. Vesi- ja ympäristöhallitus. 11 p.

JUSSILA, L. & PENTTILÄ, A. 1996. Kompostisikalan hoitokone. Koneviesti 44, 2: 6-7.

KAUFMANN, R., HELLER, W. & BIERI, M. 1997. Nährstoffbilanz im Kompoststall für Mastschweine. Argarforschung 4 (1): 25-28.

KETOLA, U. 1994. Tuottajien kokemuksia kompostikuivikejärjestelmistä 1994. LSO Alkutuotanto. 13 p. (saatavana LSO, Forssa)

KLEMOLA , E. 1998. Purupohjaiset sikalat. Työtehoseuran julkaisuja 385 . 82 p.
KOLHI, I. 1995. Kompostikuivikejärjestelmä. Opas ja tuottajien kokemukset-95. Päättötyö. Uudenmaan maaseutuopisto, Hyvinkää. 29 p.

KOLHI, I. 1995. Kompostikuivike järjestelmä. Opas ja tuattajien Kokemu Kset-95. Päättötyö. Undenmaan maa seutuopisto, Hyuinkää. 29 p.

KOTKASAARI, T. & VÄÄNÄNEN, E. 1996. Maatalousrakennusten mitoitus MRO C 1. Maa- ja metsätalousministeriö. 19 p.

LAINE, K. 1997. Purupohjasikalaselvitys. Maa- ja metsätalousministeriö. Maaseutu- ja luonnonvaraosasto. Rakentamisyksikkö. 23 p.

PENTTILÄ, A. 1995. Alkukasvatus purupohjalla. Koneviesti 43, 17: 12-13, 15.

PENTTILÄ, A 1996. Traktorikäyttöinen purusikalan kääntölaite. Koneviesti 44, 10: 14-15.

PUUMALA, M. & PYYKKÖNEN, M. 1997. The energy balance of the sawdust deep litter system. NJF Technia ´97. NJF-Seminar 272, 1-12. 5 p.

PYYKKÖNEN, M.1994. Alustava selvitys purupohjan toiminnasta sikalassa. Raportti. 11 p. (Saatavana MTT/Vakola, Vihti).

PYYKKÖNEN, M. 1995. Purupohjan ongelmille etsitään ratkaisuja. Lihatalous 53, 7: 18-19.

PYYKKÖNEN, M. 1996. Viljelijöitä ei pidä yllyttää toimimattomaan systeemiin. KM Vet 2, 4: 6-7.

SUOMI, A. 1995. Kompostipohjainen sikala tarvitsee hyvän ilmastoinnin. KM Vet 1, 3: 11.