EQUIPMENT FOR PIG PRODUCTION

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Summary

The selection of equipment for pig production must be based on achieving efficient pig production with a low environmental impact. A comfortable environment for the animals must be created. The excretion of minerals (N, P and K) must be minimized to avoid pollution of water. In terms of aerial environment the release of ammonia, dust, noxious gases and greenhouse gases should be kept at a minimum. This will both benefit the welfare, health and performance of animals in the production systems as well as the environment pollution. Precision feeding, precision climate control and adequate manure removal, handling and application technology can be used to reach these objectives.

1. Introduction

Rapid increase in pork production can be observed over recent decades, with an emphasis on efficient production but little concern for the environmental issues of pig waste. On entering the third millennium the pork production process is in transition to a production system with a more sustainable character. The production, handling and application of pig waste and avoidance of aerial pollution from pig husbandry are important elements in this process. Nutrient surpluses in the soil may create pollution of ground and surface water.

Pig production contributes to the production of greenhouse gases, most notably methane, but also significant amounts of carbon dioxide and nitrous oxide are released. As far as eutrophication is concerned ammonia is by far the most important, followed by nitrogen oxides. Dust may contribute to respiratory diseases.

2. Environmental Impact of Pig Production

The total environmental load of a pig production system is caused by several factors. It is complex and thereby difficult to determine the total load. A Life Cycle Analysis (LCA) is a widely used methodology to calculate the load. The load in a LCA consists of the global warming effect, the depletion of the ozone layer, acidification, eutrophication, heavy metals, the carcinogenic effects, the contributions of winter and summer smog and the use of pesticides. Pig production systems have not yet been analyzed and quantified with LCA techniques. Furthermore the tool of LCA is still under development to include other factors like the effect on the landscape as well. However it is good to realize that all these effects should either be known or estimated to assess the environmental impact of a pig production system. A pig production system with a low environmental impact may also include recycling dead animal corpses.

2.1 Minerals

When excess loads of minerals are applied to land, some environmental problems may arise. In several countries the amount of manure that can be applied to the field is related to the N and/or P in the manure and amounts that relate to crop intake can be applied.

In the Netherlands the amount of P_2O_5 that may be applied to the field has been limited to 80 kg ha^{-1} from 2002 onwards both for pasture and arable land and thereby brought in balance with the crop intake. In areas with high concentration of animals, this means that the minerals produced with the manure cannot be fully utilized within the region, but that minerals need to be transported to areas with less manure production like arable farm regions.

As far as N is concerned the concentration of NO_3^- in groundwater should not exceed 50 mg L^{-1} within the European Union, whereas surface water should not contain over 2.2 mg of N per liter. This standard is still exceeded in several areas. In addition to nitrogen, potassium (K) is a mineral for which a maximum level in drinking water has been set (12 mg L^{-1}). It implies that K application to fields have to be monitored as well. The flows of minerals like N, P, K and heavy metals like Cu, Zn, Pb and Cd from pig production to agricultural land may lead to contamination of ground water, surface water and soil. In the Netherlands the leaching on arable land of Cu, Zn, Pb and Cd is estimated to be 78, 207, 14 and 2.6 g ha^{-1} a^{-1} on sandy soils.

2.2 Greenhouse Gases

The contribution of carbon dioxide from fossil fuels to global warming (estimated at 49%) is considerable. Industry, traffic and domestic production are major sources but agriculture also contributes. The contribution of pig farms is estimated to be 1% for the

Netherlands. It should be noted that the energy use in livestock production might also include a substantial amount of energy not consumed on the farm but earlier or later in the production chain. The energy input of various activities in the production of pork under Dutch circumstances is estimated to be 9700 kJ kg^{-1} of live weight.

The CH_4 contributions to global warming are estimated at 15 to 20%. The global contribution of the livestock industry to total methane emission is 15 to 30%. In some regions the contribution is higher.

In the Netherlands the methane emission originates from 40 to 50% of the livestock industry, in Germany 46%. Increases in methane emission from animal production are the most important single anthropogenic source (29% of total), with 75% from enteric fermentation (mainly cattle) and the remainder from decomposing animal wastes under anaerobic conditions.

Nitrous oxide (N_2O) emissions contribute 6% to global warming. After energy use and bio mass burning, fertilizer use is the third main source of N_2O emission. Pig production may play a positive role in this process when it leads to fertilizer replacement. The litter in pig houses may produce nitrous oxide in a nitrification/denitrification process.

2.3 Eutrophication and Acidification Factors

Acidification and nitrogen enrichment of terrestrial and aquatic ecosystems is caused by sulfur dioxide, ammonia and its chemical combinations (NH_x) and nitrogen oxides. Ammonia in the air originates mainly from animal production, 74% of total in Western Europe as a whole, 92% of total in the Netherlands. In 1989 NH_3 was responsible for 46% of the acidification in the Netherlands.

The contribution from pig production to total agricultural production of ammonia, when low emission techniques during application were not yet used, was 37%. It is generally accepted that ammonia is the most abundant gas-phase alkaline component in the troposphere, and total global production of ammonia from pig husbandry has been estimated to be 2.8 Tg N per year.

The main effect of ammonia emission at soil level is the nitrogen enrichment of nutrient-poor regions, what may lead to extinction of nitrophobic species like heather. Conversion of ammonia to nitric acid stimulates acidification of soils and lakes. High levels of ammoniacal nitrogen can also reduce the availability of potassium and magnesium.

Ammonia emission in the Netherlands has been showing a declining trend over recent years, mainly as a result of new slurry application techniques and because of the requirement to cover manure storage. While ammonia emission in 1990 still stood at 222 million it had been reduced to 172 million kg in 1994.

Ammonia deposition near pig operations may be over 100 kg of N per hectare per year. Such deposition levels have to be taken into account when calculating nutrient balances.

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Bibliography

Aarnink A. J. A. (1997). Ammonia emission from houses for growing pigs as affected by pen design, indoor climate and behaviour, Ph.D. thesis. Wageningen, The Netherlands. 175 pp. [Experiments and model to quantify ammonia volatilization.]

Baxter S. (1984). *Intensive pig production*, 588 pp. London: Granada. [Handbook on pig production and pig housing design.]

Canh T. T. (1998). Ammonia emission from excreta of growing-finishing pigs as affected by dietary composition. Ph.D thesis. Wageningen Agricultural University, The Netherlands. 163 pp. [Experiments to quantify effects of dietary components in pig nutrition on ammonia emission.]

Miner J. R. (1995). *A Review of the Literature on the Nature and Control of Odors from Pork Production Facilities*, 118 pp. Des Moines: National Pork Producers Council. Iowa, USA.

Noblet J., Dourmad J. Y., and Dubois G. (1993). In *Proceedings of the First International Symposium on Nitrogen Flow in Pig Production and Environmental Consequences*. (ed. Verstegen M. W. A., den Hertog L. A., van Kempen G. J. M., and Metz J .H. M.), pp. 189–194. PUDOC, Wageningen, The Netherlands. [Description of nutrition possibilities to reduce mineral excretion of pigs.]

Van 't Klooster C. E. (1996). Animal-based control algorithm for natural ventilation in pig houses. *Transactions of the ASAE* **39**, 1127–1133. [Intelligent natural ventilation in pig houses.]

Van 't Klooster C. E. and Metz J. H. M. (1998). Pig waste disposal: mechanisms and implications. In *Proceedings of the 15th International Pig Veterinary Society*. Birmingham, UK. Vol. 1, pp. 267–272. [Description of stages and technologies to ensure sustainable manure utilization.]

Zhang Y. (1994). *Swine Building Ventilation*, 136 pp. Saskatoon: Prairie Swine Centre Inc. [Overview for engineers of climate control in pig houses.]

Biographical Sketch

Cees E. van 't Klooster was born and raised on a farm in the Netherlands. He obtained his B.Sc., M.Sc. and Ph.D. degrees in agricultural engineering from Wageningen University. In 1978–1979 he worked at the Center for Agricultural Research in Surinam. From 1981 till 1984 he was employed by Eindhoven University of Technology and assigned as lecturer in the Department of Agricultural Engineering to the University of Zambia in Lusaka. From 1984 till 1986 he worked for Wageningen Agricultural University as lecturer both in Zambia and in Wageningen. In 1986 he joined the Research Institute for Pig Husbandry in Rosmalen as researcher climate control. In 1994 he joined the Institute for Agricultural and Environmental Engineering (IMAG) in Wageningen. His current position is head of the Department of Livestock Production Engineering. His professional duties include membership of the CIGR working group on Aerial Environment in Animal Housing and chairman of the ISO/TC23/SC19 Working Group ‘Animal Identification’. He is involved in several EU projects. He has published over 100 articles in technical and scientific journals, mainly on topics related to pig housing, some on poultry and cattle.