ENVIRONMENTAL IMPACT OF PIG MEAT PRODUCTION

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ABSTRACT

The aim of this paper is to examine the environmental effects of pig production and possibilities at farm level to limit these effects. According to the "EC Nitrate Directive" the application of animal manure should not exceed 170 kg N/ha. Supply of animal manure in the 12 European member states exceeds 170 kg N per ha, approximately 13% of the number of holdings. The production of nitrogen from animal manure at member state level exceeds 170 kg N/ha in Belgium and the Netherlands. The performance and mineral excretion per sow and per fattening pig on Dutch farms in 1995 were estimated using data from 362 sow farms and 631 farms with growing-finishing pigs. Average annual P205-excretion per sow and per fattening pig amounted to 14.0 and 5.0 kg/year respectively. Average annual N-excretion per sow and per fattening pig amounted to 30.8 and 13.2 kg/year respectively. Observed differences between farms in annual mineral excretion per animal are large. Farms with low annual mineral excretion have better productivity figures. The possibilities of reducing the mineral excretion are mainly dependent on the onset of the situation. In many cases lowering the mineral content in the feed alone will not be sufficient. There are possibilities for reducing the mineral excretion level but it takes time to implement the appropiatte measures and they are not feasible for all farms. The emission of ammonia from animals which is produced in the barn can only be reduced by allowing new housing systems that meet specific environmental requirements. The emission of ammonia can be diminished by reducing the emitting surface, the slurry temperature, the air movement above the emission surface, the N contents and the pH of the slurry. Over the last few years, low emission housing systems for each pig category have been developed.

INTRODUCTION

In the main livestock areas of the European Union, farm structure has changed from many dispersed crop-livestock operations to few large scale livestock farms that are specialized in dairy, pigs or poultry. Regional and on-farm specialization have caused a concentration of production.

Current animal husbandry practices have their origin in the economics of agricultural production technology. Farms continue to increase in size because the capital outlays required for new technologies are often beyond the financial capacity of small farms. By increasing farm size the investment is spread over more units of production. Productivity increases while per unit cost decreases. As a result of changing farm size, farming has become much more mechanized and intensive, with greater on-farm specialization and increased regional concentration.

With more specialized livestock production more nutrients in the form of feedstuffs are brought into a region than when the livestock operation is part of an integrated crop-livestock operation. Typically, only about one-third of the imported nutrients leave the specialized livestock farm with the marketed animal or animal products (Lanyon, 1992). The remaining two-third of the nutrients are either deposited in the manure or emitted in the air.

With the exception of poultry manure, livestock manure is costly to transport, because it contains large amounts of water. To reduce overall production costs, manure was often spread on nearby farm fields with little attention paid to the nutrient requirements of the crops grown. Over time the disposal of manure has increased the burdens placed on local environments that were not able to recycle these surplusses of nutrients with the emphasis on phosphorus and nitrogen. Consequently, the assimilative capacity of the natural environment for a surplus of nutrients in the manure has been exceeded in certain areas.

A concentration of intensive livestock production in certain areas is a common feature of many livestock producing countries all over the world. In the Netherlands, the adverse effects of intensive livestock production on the environment have received considerable attention since the early 1980's. Today, environmental concerns are raised in other intensive livestock areas of the European Union, Asia and the USA.

During the decades since World War II agricultural productivity growth has been able to more than compensate for the rapid growth in food demand. As we look in the future, however, the sources of productivity growth are not as apparent as they were a quarter century ago. The demands that the developing economies will place on their agricultural producers from population growth and growth in per capita consumption arising out of higher income will be exceedingly high. The absolute increases in population size will be large and increases in per capita incomes will add substantially to food demand.The effect of growth in per capita income will be more rapid growth in demand for animal proteins and for maize and other feed crops. Many countries will experience more than a doubling of food demand before the end of the second decade of the next century (Ruttan, 1991) making improvement of the efficiency of meat production a major challenge for the scientific community.

This paper is aimed at the environmental effects of animal production, especially pig production, and possibilities at the farm level to limit these effects, by reducing ammonia emission and improving nutrient efficiency.

EFFECTS ON THE ENVIRONMENT

The general concerns of the public regarding adverse effects on the environment of intensive animal production include:

(1) Location of the building (noise, appearance, smell);

(2)Run-off from manure application (production of nitrates, oxygen absorption in flowing water, leaching of organic compounds, nitrogen and phosphorus);

(3) Inadequate manure storage capacity (suboptimal application times); and

(4) Atmospheric emission of ammonia (acidification of the environment).

The problems of air, soil and water pollution caused by intensive animal husbandry vary in character and degree from country to country and region to region. These problems can be expressed in terms of health, nature conservation and landscape amenity, and quality of natural resources (Rainelli, 1989). The magnitude of the necessary reductions is still under discussion.

Today air pollution is regarded as being worse than a few years ago. In areas where pigs, poultry and cattle production are highly concentrated, animal production is considered to be a major contributor to ammonia emission into the air. This has affected the vegetation. Acid rain will diminish if less NH_2 is produced and consequently less ammonia falls on the ground.

Ammonia from animals is produced in the barn by decomposition of urea and other nitrogenous compounds. Moreover, ammonia is emittted during the application of manure on the field. The ammonia emission is given by Asman (1987) as values per animal (place) per year. Ammonia emission per animal per year in the Netherlands ranges from 0.26 kg NH_3 in chickens to 18.20 in cattle and 9.43 in horses. Pigs, sheep, goats and asses have intermediate values of approximately 3 kg.

The amount of dust produced will mostly depend on the type of animal and the housing and feeding system. Normally, chickens produce more dust than either pigs or cattle. Carbon dioxide is produced as a result of the metabolism of animals. It has been estimated that a pig of 50 kg receiving 2 kg of a diet will produce about 600 litres a day. Since a fattening period is about 100 days this corresponds with a production of 60,000 litres or 120 kg of CO_2.

The leaching of nitrate into the water from the application of manure can create a health problem. The level of 50 mg of nitrate per litre of potable water suplies is at times exceeded. At present it is now well accepted that phosporus and nitrogen application have to be reduced in order to reduce eutrophication of surface water.

ENVIRONMENTAL POLICIES

Governments are developing environmental policies that try to take into account environmental costs and benefits as well as income consequences. Depending on the pollution source, policies have a regional, national or supranational character.

An important European directive is the so called "EC Nitrate Directive" which implies that the application of animal manure should not exceed 170 kg N/ha (including manure from grazing livestock). This is to be achieved under the Nitrate Directive in zones which are identified to be vulnerable for leaching of nitrate.

Supply of animal manure in the 12 European member states exceeds 170 kg N per ha on approximately 13% of the number of holdings represented by the Farm Accountancy Data Network (FADN) of the European Commission.The production of nitrogen from animal manure at member state level exceeds 170 kg N/ha in Belgium and the Netherlands. This means that these countries are unable to meet the Directive according to present farming practice (Brouwer et al., 1995).

The ammonia problem will be assessed and tackled by various governmental measures. Among these measures are regulations with respect to rates and methods of land application of manure. The emission of ammonia from animals which is produced in the barn can be reduced by allowing only new housing systems that meet specific environmental requirements.

NUTRIENTS

The annual mineral excretion (before emission) on specialized livestock farms can be estimated using the equation:

Annual mineral excretion = mineral in purchased animals + mineral in purchased feed - mineral in marketed and culled animals/products

For computing the amount of minerals in purchased animals and marketed and culled animals, the mineral retention of the livestock animals can be derived from literature by Coppoolse et al. (1990). Coppoolse et al. (1990) calculated that 26% of the N-intake will be emitted as ammonia.

In pigs, the impact of microbial phytase, synthetic amino acids and other measures, that reduce the annual mineral excretion per animal were estimated by Van Zeijts and Backus (1995). In their economic study, performance data were used of the average type of farm. For example, a reduction in the total P-concentration of sow and piglet feed of 0,1 g per kg feed was associated with a decrease in P_2O_5-excretion of 0.25 and 0.14 kg per sow and year, respectively. A reduction in the P concentration of growing-finishing pig diets with 0,1 g per kg feed was associated with a decrease in P_2O_5-excretion of 0.18 kg per growing-finishing pig and year. However, it should be pointed out that the association between dietary P- and N-concentrations and the annual mineral excretion are only valid when the dietary P- and N-concentrations are within the normal range.

DIFFERENCES BETWEEN FARMS IN MINERAL EXCRETION PER ANIMAL

The annual P_2O_5-excretion excretion per sow and per growing-finishing pig were estimated using farm data over the year 1995 (van Brakel and Backus, 1996). Data over 1995 contain annual results from 362 sow farms and 631 farms with growing-finishing pigs. In Tables 1 and 2, the performance and annual P_2O_5- and N-excretion data of commercial sow and growing-finishing pig farms are presented. A distinction is made between the 25% farms with the highest and the lowest annual P_2O_5-excretion per sow or growing-finishing pig.

Table 1:Performance and mineral excretion per sow on Dutch farms in 1995.

P_2O_5-excretion per sow/year	25% lowest	25% highest	average
Sold piglets per sow per year	21.3	21.1	21.5
Price sow feed (Dfl/100 kg)	39.19	39.59	39.29
Price piglet feed (Dfl/100 kg)	59.72	61.59	60.54
Margin over feed costs (Dfl/sow /year)[1]	840	767	814
Piglet feed (kg/piglet)	27	31	29
Sow feed (kg/sow/ year)	1046	1099	1076
P-content piglet feed (g/kg)	5.2	5.6	5.4
P-content sow feed (g/kg)	4.7	5.3	5.0
N-content piglet feed (g/kg)	27,6	28,7	28,3
N-content sow feed (g/kg)	22,9	24,4	23,5
P_2O_5-excretion (kg/sow/year	11.9	16.5	14.0
N-excretion (kg/sow/year)	27,1	34,6	30,8

[1] The computation of the margin over feed costs is excluding manure disposal costs.

The difference in mineral excretion between the proportion of farms (25%) with the highest and lowest annual P_2O_5-excretion was 4.6 kg P_2O_5 and 7.5 kg N per sow, respectively. This difference was primarily due to a reduced P- and N-concentration in the sow and piglet feed. But also the amount of sow feed consumed was low on the sow farms with the best performance.

Table 2: Performance and mineral excretion per finishing pig on Dutch farms in 1995

P_2O_5-excretion per pig/year	25% lowest	25% highest	average
Daily gain (g)	740	732	734
Feed intake (kg/day)	2,00	2,08	2,04
Feed conversion ratio(kg/kg)	2,70	2,84	2,79
P-content feed (g/kg)	4.4	5.3	4.8
N-content feed (g/kg)	26,6	27,1	26,5
Feed price (Dfl/100 kg)	42.73	41.47	41.83
Margin over feed costs (Dfl/pig/year)[1]	130	114	120
P_2O_5-excretion (kg/pig/year)	3.9	6.4	5.0
N-excretion (kg/pig/year)	11.7	14.4	13.1

[1] The computation of the margin over feed costs is excluding manure disposal costs.

In 1995, the respective differences were 2.5 kg P_2O and 2.7 kg N per growing-finishing pig and year between the 25% farms with the lowest and the highest P_2O_5-excretion. The high difference can partly be explained by the P-and N-content in the feed and partly by the 0.14 units difference in feed conversion ratio.

The annual P-excretion per broiler and per laying hen are estimated using farm data of the period February-September 1994 (Voet and Koldeweij, 1996). The estimated annual P_2O_5-excretion per laying hen and per broiler are calculated for 50 broiler farms and 55 farms with laying hens that have implemented a mineral accounting system. The performance data of these farms are not available for publication. Annual P_2O_5-excretion per broiler equaled 0.19 (s.d.= 0.03) kg. Annual P_2O_5-excretion per laying hen is 0.50 (s.d. = 0.08) kg.

POSSIBILITIES TO REDUCE THE MINERAL EXCRETION

In a recent study, the extent to which phosphate and nitrogen excretion on pig farms could be reduced and the measures required to do so was investigated (van Wagenberg and Backus, 1997). This was achieved by looking at whether and how pig farms could realize a phosphate excretion of 4.2 kg per fattening pig per year and 14.0 kg per sow per year (including piglets up until weaning) and a nitrogen/phosphate excretion ratio of respectively 2.9 and 2.0.

Farms were classified according to high and low feed consumption, high and low production (growth per day and number of raised piglets), small, middle and large farms and (for 1996/1997) normal and low mineral contents in the ration. In the situation at onset the calculated phosphate excretion varied from 3.99 to 5.41 kg per fattening pig per year and from 11.02 to 14.74 per sow per year. The nitrogen excretion varied from 10.84 to 13.86 kg per fattening pig per year and from 26.20 to 35.92 per sow per year.

Selected measures to reduce the mineral excretion were evaluated with respect to slaughter pig production. These measures were categorised according to management and ration composition.

Management measures may lead to an increase in the economic performance per pig per year on some farms. This will only take place when the farmer takes the correct measures. Management measures mainly influence the mean feed consumption. Examples of possible management measures are optimizing the feeding schedule, reducing spillage, optimizing the initial live weight and delivery weight, climate control and optimizing the grouping strategy at onset. Some farms will only be able to take such measures after having invested in new equipment (heating and isolation of buildings). The positive effects of the measure on the economic performance are (largely) nullified by the necessary investment costs. Before management measures can be taken, the pig farmer must gain an insight into the possibilities on his farm. This process can be supported by counseling. Furthermore pig farmers can reduce the mineral content in the ration. This can be done by reducing the mineral content in the feeds used, which implies an increase in the feed price and the feeding costs (the technical results do not change). Another possiblity is to switch to three phase feeding which in some cases requires an investment in an extra feed silo and/or a new feeding system. The effect of three phase feeding is dependent of the mineral content in the feeds usually used. The lower the content, the smaller the effect of three phase feeding and the higher the increase in feeding costs.

The relation between mineral content in the feed, feed price and the expected effect on mineral excretion and feed costs is estimated by van Wagenberg and Backus (1997).

Table 3. Relation between mineral content in the feed (g/kg), feed price (Dfl/100 kg) and the expected effect on mineral excretion (kg/animal/year) and feed costs (Dfl/year).

	N normal	N low	P normal	P low	additional feed price	reduced excretion P_2O_5	reduced excretion N	additional feed costs
feed for pregnant sows	24	21.6	4.6	4.1	0.50			
feed for lactating sows	27.2	24.8	5.3	4.8	0.40	1.2-1.3	3.8-4.1	16.0 - 18.0
feed for piglets	30.1	28	5.5	5.5	1.50			
feed for starter pigs	28	26.4	5.2	5.2	0.90			
feed for finishing pigs	25.6	24	4.7	4.2	0.10	0.6-0.7	1.1-1.2	1.80 - 2.0

Table 4. Percentage of pig farms that can take management measures to reduce mineral excretion and its effectiveness.

	Farms (%)	P_2O_5 (kg/yr)	N (kg/yr)	Econ. Performance* (Dfl/pig/yr)
Finishing pigs				
Optimizing feeding schedule	7	0.11	0.27	+ 4.70
Reducing spillage	9	0.19	0.44	+ 5.00
Delivering fewer too heavy pigs	50	0.06	0.14	+ 4.10
Optimizing grouping strategy at start	2	0.08	0.22	+ 7.40
Three phase feeding(1)	5	0.2/0.19	0.3/0.65	- 8.00/+ 0.50
Sows				
Optimizing feeding schedule	19	0.48	1.09	+ 23.00
Reducing spillage	12	0.48	1.09	+23.00
Heating for pregnant sows	17	0.30	0.68	- 40.00

(*) Effect on margin of revenues over costs, excluding labour costs and manure disposal costs.
(1) low/high mineral content in the feed

By using feeds with a low mineral content in combination with management measures, most farms with fattening pigs will have a phosphate excretion of between 4.0 and 4.5 kg per fattening pig per year. A number of farms will have to cut the feed consumption through a combination of measures: reducing spillage, split-sex-feeding of barrows and sows and optimization of the feeding schedule. These measures may lead to a better economic performance per fattening place. However, the necessary adjustments are not easy, will take time and will not be possible on all farms.

Farms with sows with normal mineral content in the feed will only be able to meet the proposed nitrogen standard of 28.0 kg per sow per year with additional management measures. These farms will also have to reduce the mineral content in the feed. Most farms with sows will meet a phosphate standard of 14.0 kg per sow per year if the feed used has a low mineral content. A nitrogen/phosphate excretion ratio of 2.0 : 1 will remain a problem for a number of farms with sows. These farms will only be able to meet the mentioned figures if they can reduce the feed consumption drastically by reducing spillage and by optimization of the feeding schedule. For some farms with sows heating of the room for pregnant sows may be a solution.

The research on feedstuffs has shown that the apparent digestibility of P is highly variable among feedstuffs of different origin. In addition to the feedstuffs origin, the most important factors are the concentration of phytate and total P and the presence of intrinsic phytase. Since 1995, the Dutch feed industry has routinely added microbial phytase to pig and poultry diets. The microbial phytase has proved to be effective in enhancing P-digestibility of phytate P present in vegetable feedstuffs of pig and poultry diets (Beers and Jongbloed, 1993; and Simons and Versteegh, 1993). The use of synthetic amino acids can contribute to a reduced level of N in compound feed. There are, however, limits in reducing dietary P- and N-concentration in feedstuffs, especially when daily feed intake is low. Moreover, the amount of manure and minerals is not the only thing that counts. Also the origin of the feedstuffs is important when assessing the environmental sustainability of animal production. In countries where the pig industry is located nearby dense population areas, the use of by products of the humane food industry can bring new major opportunities.

POSSIBILITIES TO REDUCE THE AMMONIA EMISSION

The emission of ammonia can be diminished by reducing the emitting surface, the slurry temperature, the air movement above the emitting surface, the N content and the pH of the slurry. The same measures (except for the pH in slurry) can be used to reduce odour emission. Over the last five years, low emission housing systems have been developed. The systems adhere to the requirements as stated in the EU and Dutch legislation. Based on the requirements in Dutch environmental policy pens for pigs have been redesigned (Verdoes et al., 1996). In Table 5, the reductions in ammonia emission of these redesigned pens are compared with the standards as published by the Dutch government (den Brok et al., 1997).

Table 5. Ammonia emission from pig pens of standard and new designs (kg NH_3/pig place).

Room	Standard	New designs	% Reduction range
Dry sows	4.2	1.8-2.5	40 - 57
Farrowing rooms	8.3	2.4-4.0	52 - 71
Nursery rooms (partly slatted)	0.6	0.13-0.30	57 - 75
Growing/finishing pigs	2.5	1.0-1.5	50 - 67

CONCLUSIONS

Farming practice needs to be adjusted. The application of animal manure at other farms will gain importance. Costs of transport of animal manure will increase. The possibilities of reducing the mineral excretion are mainly dependent on the situation at onset. In many cases lowering of the mineral content in the feed alone will not be sufficient. Farms with an average or high feed consumption will have to adjust their management. There are possiblities for reducing the mineral excretion level but it takes time to implement the suitable measures and they are not feasible for all farms.

It can be concluded that over the last few years, low emission housing systems for each pig category have been developed. These low emission systems adhere to the requirements as stated in the EU and Dutch legislation. Moreover, observed differences in annual mineral excretion per animal are large. Both management measures and reducing the mineral content in the feed ration can contribute to reduced mineral excretion levels.

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