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Contrasting the management of livestock manures in Europe with that practised in Asia: what lessons can be learnt?

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Similarities exist in livestock farming in Europe and Asia. There is close coupling of intensive agriculture with industrialisation and environmental impacts caused by the production of very large amounts of organic wastes in limited areas. There are also differences deriving from, geographical, climatic and cultural factors that have led to some special problems in each region. In Europe, there is still a lack of appreciation of the full agronomic value of the manures produced although most are spread in an organised way. In Asia, the solid dung is more likely to be valued and sold as a product for fish farms and vegetable or fruit production. However, land for spreading is limited and less accessible and river pollution is commonplace. In both regions, effective treatment options are available but in the absence of financial support, they are rarely popular unless a financial return is implied such as in biogas schemes.

Keywords : European agriculture, Asian agriculture, pigs, poultry, beef, fish, environmental impact, water and air pollution, abatement measures, food safety, hygiene, legislation.

1. Introduction

European livestock agriculture moved to intensive systems in the mid-twentieth century with most animal production coming from modern units by the 1960's. Industrialisation has occurred more recently in Asia and in a more patchy way with the development of major centres focussed on the principle cities in the region such as Ho Chi Minh (Vietnam) and Guangzhou (China). With the relative increase in the urban standard of living, the preferred diet moved from one of principally rice and vegetables to include more meat product. Asian countries now account for one third of cattle production and more than half of pig production (Windhoarst, 2006). The period of growth in the livestock industry in Asia is far from levelling off in the way observed in Europe in recent years. One might note that, in the early nineties, Europeans consumed an average of 78 kg of meat and 178 kg of milk products per person per year. By contrast, developing Asian countries (including China), were then consuming only 18 kg and 12 kg of such products respectively. (Ehui et al., 1998). Animal production in Asia is set to continue its expansion for the foreseeable future (Gerber and Menzi, 2006) with meat production from Asian countries greatly exceeding that in Europe over the coming decades. The negative impact on the environment from the growing livestock industry in Asia is evident from the visual contamination of land and surface waters. The wider impact is apparent from studies on the inevitable development of nutrient surpluses in areas of high production with the expected longer term pollution consequents (Gerber et al, 2005).

When comparing European agriculture to that emerging in Asia, the impression might be that Europe has largely passed through the negative phase and that it can now be used as a model for livestock agriculture in Asia and other developing areas of the world. There is certainly some scope to transfer some of the successful techniques where there is common ground. However, there are also geographical differences that require a very different approach in Asia. And in

some instances, noting that balancing agriculture and the environment in Europe certainly remains to be achieved, there may yet be lessons to be learnt.

2. Current manure handling practices in Europe

Most livestock manure generated within Europe is applied direct to cropland near the farm. In principle, this can represent the simplest solution with the fewest problems so long as:

- There is enough local land to accept the applied nutrient load;
- Timely applications can be made as required by the crop;
- The land is not susceptible to run-off (sloping ground)
- The fields are not near residential housing
- There is little risk of crop contamination or animal health problems.

In reality, this is often the situation with cattle farms where local pasture is plentiful but for pig and poultry units, land is often lacking and treatment methods are implied to deal with the surplus nutrient. However, even if there is enough land and the system appears to be in balance, problems can still arise if manure is then applied in a hasty or ill-considered way. Thus in many parts of Europe, manure management plans are encouraged to ensure a systematic spreading regime. This includes the identification of suitable fields and matching applications to the crop requirement (and reducing the use of chemical fertiliser accordingly). For liquid manure, field access problems may be overcome by pipeline transfer and irrigation systems (Figure 1). This may require prior separation of the collected slurry; efficient mixing systems are also implied. Minimum store capacity is often specified to ensure that spreading can be avoided during adverse weather conditions (eg: frozen or water-logged ground). Improvements are also possible with application equipment design including injection to reduce emissions of ammonia and odour. There has also been some development of intelligent application systems using GPS positioning to control applications automatically depending on field and season but this remains at a research stage (Carton O.T. and Lenehan J.J.; 1998).

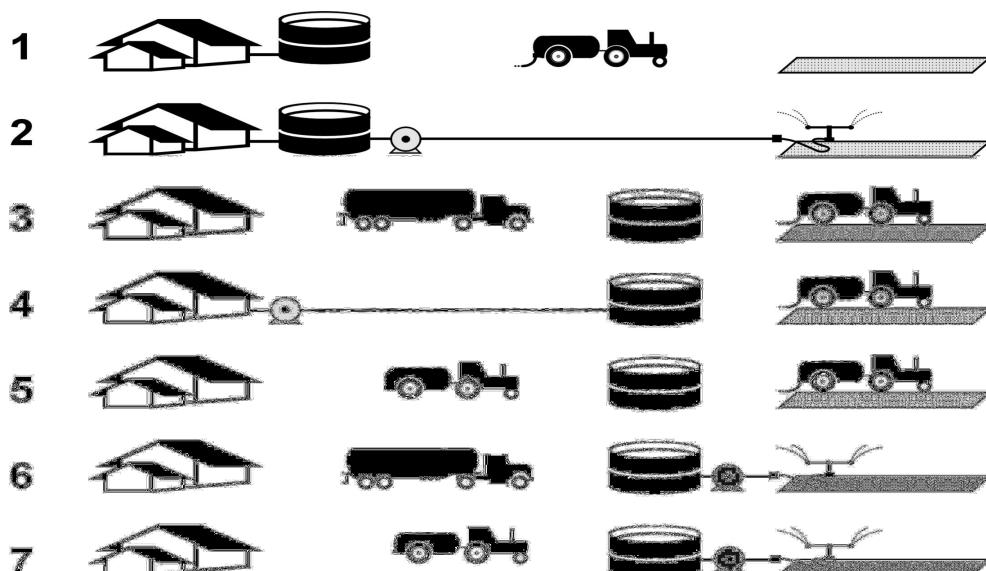


Figure 1: the main transport scenarios for the land application of liquid manures and other farm effluents. Stores can be located near to animal buildings (1, 2) or close to the point of land application (3-7). For the former, conveyance to the field can be by tanker or pipeline to irrigation equipment. Field stores located away from the farm can be supplied by tanker or pipeline. Road haulage would need to be used where long distances were involved.

2 In situations where the local field capacity is exceeded, surplus nutrients must be removed if they
4 are not to ultimately contribute to an undesirable environmental impact. Road haulage (or for
6 shorter distances, pipeline transfer) as illustrated in Figure 1, has been used in parts of Europe,
8 especially the Netherlands as a direct method to re-distribute manure surpluses. However, the
environmental impact of the extra transport must be included in any assessment. Pipeline
transport is easier once the initial investment has been made but pre-treatment to remove some
suspended matter is necessary and the engineering problems increase with distance.

10 The destruction of components within the manure is specifically the nitrogen load (by
12 aerobic/anoxic treatment) or organic load (by aerobic or anaerobic treatment). Nitrogen removal
14 is via a process of nitrification (ammonia converted to nitrites and/or nitrates) followed by de-
nitritification (nitrites and nitrates broken down to di-nitrogen gas). The technique is used in the
16 Brittany region of France to deal with nitrogen surpluses (Beline et al, 2004). Any biological
18 process can be expected to breakdown organic matter; for aeration, this will be to carbon dioxide
20 and water; for anaerobic processes, this will be to acetic acid then methane. Components of
22 manure that can not be eliminated (such as phosphorus or heavy metals) can only be removed by
24 separation, concentration and exportation (Daumer et al, 2004). Indeed, this may be desired for
26 all excess nutrients including nitrogen and organic matter when there is a recognised value.
Separation can be by screening machines but these have a limited effect on finer suspended
particles. Alternatively, there is sedimentation which is often by gravity using large shallow
vessels; this typically results in sludges with concentrations between 5 and 10% dry matter
(Martinez and Burton, 1995). The process can be accelerated and extended by the use of a
decanter centrifuge which can take the concentration of the sludge to over 30%. Solid products
whether sludges, screened materials or solid litter, can be blended with wheat straw and
composted to produce a potentially useful organic product sometimes saleable.

28 3. Livestock manure management in Asia

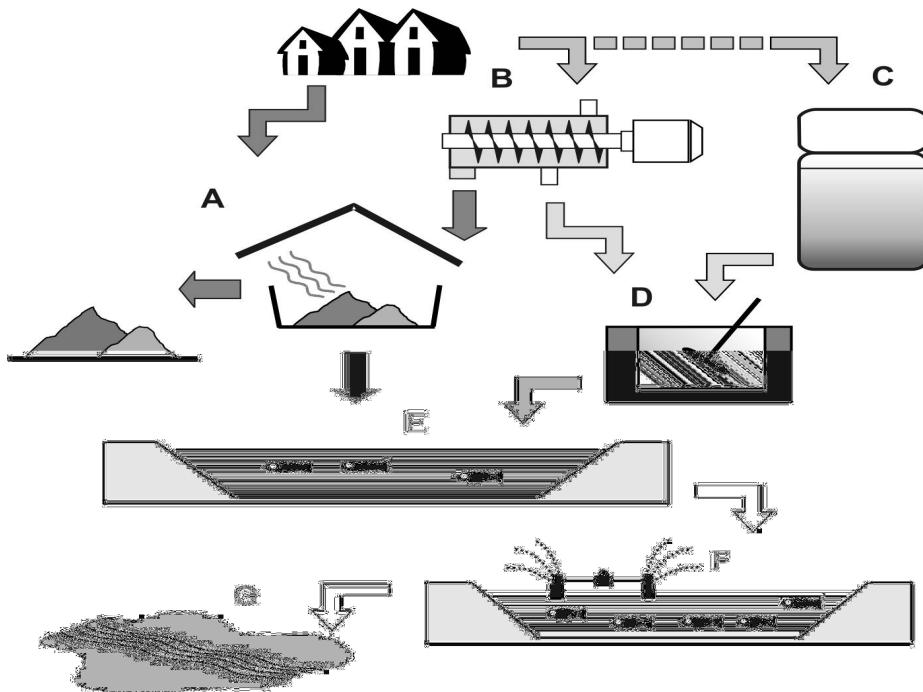
30 In Asia, the largest numbers of animals are reared close to the major population centres. This
32 has resulted in the development of an expanding livestock industry that has become quickly
34 swallowed up in the growing suburbs of the metropolis. However, such farms are now declining
36 in number as government policy endeavours to relocate them away from the city to more rural
regions. In time the new and larger units will benefit from the economy of scale and probably
account for most of the production. Manure management differs from that in Europe in:

- 38
- The available farmland in the peri-urban environment is very limited
 - Manure is rarely land applied because of fears of crop contamination.
 - The frequent coupling of fish and pig production
 - A greater value is given to biogas – often used for cooking
 - A greater value is given to solid dung
 - The importance of keeping the animals cool in a very hot and humid climate
 - The relative poverty of the rural region
 - Access and transport difficulties

46 The main manure handling schemes are set out in Figure 2. The solid dung is often collected
48 manually collected, dried, bagged up and sold as fertiliser for both crop and fish farms. As such
50 the related nutrients are exported but the proportion collected varies – never a pleasant task, and
52 even more difficult in the wet season of the monsoon. In some farms, the provision in the pig
pen of shallow baths to keep the pigs cool (wallows) ensure that little solid dung can actually be
collected. Thus most nutrients are still likely to remain in the liquid effluents washed from the

buildings. Biogas is a popular option both with smaller farms (where it is used in local houses) and in the larger farms schemes for electricity production are encouraged. In some regions, there is the close coupling of pig production with fish ponds, the manure from the former nourishing the environment of the latter.

6



8
Figure 2: common manure handling schemes in Asia. Solid dung is often collected and dried for export (A).
10 Large farms are considering investment in separators to enable feed for composting (B) but anaerobic digestion is
12 more popular (C). Collection systems (D) with mixing are still rare as is the related land spreading. Lagoon storage
14 including fish rearing (E) is common as is the addition to manures to commercial fish ponds (F). In many cases,
16 contamination of local rivers (G) is still a common occurrence.

18 Although solid manure products are valued in Asia, the liquid effluent is generally seen only as a nuisance and land spreading is very rare. Rice represents the main crop but both the production cycle (involving periodic land flooding) and the vulnerability of the crop to poor yields if over dosed with nitrogen make liquid manure applications very unpopular.

20 The situation in Thailand is typical of an economy advanced in development. Livestock farms fall into two main groups: small family units in the peri-urban areas and no land and very large modern farms (5000+ pigs) with the resources to deal more effectively with manures produced.
22 Pig production is moving towards the latter but the pollution impact from the smaller farm is possibly more serious as inadvertent discharge to streams (direct and indirect) is commonplace.
24 The option for biogas is limited as increasingly available electricity is preferred the odorous biogas and releases of methane may result. The exception is where the gas can be used to power fans for cooling. The reduction in pollution by lagooning systems is an option for the larger farms with available local land: the evaporation from the high temperatures leads to relatively little liquid discharge in this apparently closed system. This will enable the reduction in organic load and P (mostly accumulating in the forming sludge layer) but N losses are likely to be mostly as ammonia emissions.

32
34 Vietnam represents an example of an Asian economy at an earlier stage of industrialisation: the situation is different between the north and the south. In the north, where food production is focussed on the principle metropolis of Hanoi, pig production comes from numerous farms clustered in villages and small towns; many have fewer than a dozen or so animals. Once again
36

the solid dung is valued with quantities being collected and used to sustain adjoining fish ponds or for local vegetable production. Much of this activity takes place in the delta area of the Red River which dominates the geography of the region. Any available arable land around the edge of the village is thus given over to rice production: there is little or no structured land spreading of manures. In the relatively poor rural area the value of biogas is valued; small digesters are commonplace.

4. Environmental impacts from intensive livestock production

4.1 Water pollution

Water pollution from animal production is caused by the release of effluent through or running over soil. Nitrogen and phosphorus can be taken up by the growing crop but excesses will be released to the aquatic system; limited amounts can be immobilised in soil organic matter but only up to the system capacity. The impact of free ammonia (rather than the ammonium ion) presents the greater impact on surface water as it is toxic to many fish even at very low concentrations. In pig and cattle slurries, the proportion of N as ammonia can exceed 60 % of the total. This can be quickly nitrified after land spreading, leading to an excess of nitrates in the soil. Organic-N is not immediately available to plants but it is estimated that around half will be converted to ammonium during the first 12 months after spreading. (Choudhary et al., 1996). The phosphorus content of manure is of concern because there is a direct relationship between the amount of extractable-P in the soil and the concentration of dissolved P in the surface run-off that can produce eutrophication of surface waters that are contaminated (Withers and Sharpley, 1995). The P in manure is present in both organic and inorganic forms, but the organic fraction can be rapidly solubilised, so the mobility of P in animal manures can approach 100 %. In manures and slurries potassium is present as soluble salts, and it comes almost totally from the urine of the animals. About 90 % of K in feed is excreted by the animals. Usually, the concentration is greater in cattle slurry than for pig slurry; K availability to plants often close to 100 % (Bernal et al., 1993).

4.2 Air pollution

Animal production is a major contributor to certain sources of atmospheric pollution (Pain, 1999). The ventilation air from livestock housing will contain odorous substances, methane, nitrous oxide (N_2O) and especially ammonia all of which can detrimentally effect the environment. In Europe, CH_4 emissions originate from manure management but mostly (two thirds) from enteric fermentation of ruminants. Ammonia present in slurries largely arise from the degradation of urea. Emissions also follow field spreading and include, in addition, quantities of nitrous oxide produced from the breakdown of nitrates themselves resulting from the nitrification of ammonia in the soil.

The threat to the environment from global warming is mostly attributed to the huge amounts of carbon dioxide released into the atmosphere from anthropogenic activity. However the relatively small amounts of methane and nitrous oxide, have a disproportionate effect owing to their higher warming potentials of x25 and x300 respectively (IPCC, 1995): they now contribute around 25 and 5% of the total effect. Concentration of all three greenhouse gases have increased by 30, 145 and 15 % for carbon dioxide, methane and nitrous oxide respectively over the last 250 years (Moisier, 1998) although it should also be noted that the growth rate is increasing. For its part, agriculture contributes 25, 65 and 90 % respectively of the net emission of these gases (Duxbury, 1994). The figure for carbon dioxide is greatly increased as a result of forest clearing but emissions of methane and nitrous oxide relate closely to agricultural production. Animal wastes

contribute 10-20 % of the methane produced from agriculture. Nitrous oxide is almost entirely the result of di-nitrification of nitrates in the soil, the result of surplus applications of nitrogen whether as inorganic or organic forms. Nitrous oxide is also involved in the photochemical reactions in the stratosphere that are related to the fall in concentrations of ozone.

4.3 Disease risks and health issues

In Europe, public concern related to food hygiene have been raised in recent years due to cases of contamination of certain agricultural food products (including salmonella, e-coli, campylobacter and listeria). In addition there have been outbreaks of animal disease including foot and mouth, classical swine fever and more recently, avian influenza. Incidences of contamination of water by zoonoses are relatively few, but they often represent a very serious event with human fatalities in some cases (Guan and Holley, 2003). In response to such incidents, there have been some additional restrictions on where and how manures may be used but so far, not mandatory treatment. Suitable treatment options do exist including aeration, anaerobic treatment, use of disinfectant chemicals and prolonged isolated storage. Thermal treatments present a more rigorous and reliable approach (Turner and Burton, 1997) but the use of such technology is limited to specific areas where high risks occur. In response to the concerns on the quality of the farm produce, increasing limitations are applied on the use of manure on crops; in some of the most vulnerable crops (eg: leaf crops eaten raw), applications of manure, even treated, is discouraged. Such a trend if extended may ultimately make land application of manures as part of a farm cycle increasingly difficult.

5. The role of legislation in manure management

5.1 European environmental policy on livestock farming

Most European countries have similar regulations regarding the operation of livestock farms including (i), licensing required for large housing units, (ii), mandatory storage of manures and slurries to enable a better agronomic utilization and (iii), prohibited periods for land spreading (usually the winter months from November to February) (Mallard, 2006). The European Directive represents the main regulatory tool determining national measures with each member state implementing them with its own legislation. The Nitrate Directive (91/676/EC) fixes a limit of 170 kg nitrogen for the amount of livestock manure applied to the land each year. Going further, the Water Framework Directive (2000/60/EC) lays the foundations for a new policy on water quality, integrating all previous regulations regarding specific water pollutions or specific quality standards. The WFD defines a framework for the elaboration and the implementation of water policies, but it does not contain any “operational” measures beyond the existing regulations. However a prominent role is devoted to economic instruments such as taxes and incentives.

European policy derives from the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone (also known as Gothenburg Protocol) which was signed in 1999 and implemented in May 2005. This protocol fixes national annual emissions targets for different gases including ammonia and NOx to be reached by 2010. The related 2001 National Emission Ceiling (NEC) Directive (2001/81/EC) fixes national emissions ceilings for these gases. The global warming issue has been addressed, from the regulatory point of view, in a similar way. The Kyoto Protocol was adopted in Europe in December 1997, during the third session of the Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change.

The 1996 IPPC directive (1996/61/EC - Integrated Pollution Prevention and Control) represents a comprehensive approach. It covers all the main categories of industrial activities which are divided into a series of sectors – one of these is livestock agriculture. Any installation coming under the scheme shall not be operated without a permit covering building and operating requirements, based on best available techniques (BAT), in order to prevent or to reduce polluting emissions. A series of detailed reference documents (BREF's) has been developed to specify what constitute BAT (EIPPCB, 2006). For livestock production, the IPPC directive currently only includes the intensive rearing of poultry or pigs with more than 40,000 places (poultry) or 2,000 places (pigs).

5.2 *Environmental regulation in Asian countries*

The development of environmental regulation across many parts of Asia is established with respect of limits on effluents intended for river discharge. Controls on emissions from agriculture are less well defined although there many regulations that allude to a general protection of the environment (but without specifying measures nor targets). On paper, there are set standards in existence for most countries specifying the maximum concentrations of key polluting indicators permitted in effluents for controlled discharged to rivers and surface waters. In some countries such as Thailand, concessions are offered to small livestock farms with a higher tolerable limit such as a maximum BOD (biochemical oxygen demand) of 100 ppm whereas 60 is specified more generally. However, if there is no direct discharge to rivers, the implementation of such regulation at any level becomes vague; unintentional discharges such as might arise from an overflowing lagoon in the wet season may also be overlooked.

The main control on livestock farming is one via planning regulations which both restricts new development to approved areas and which actively encourages the relocation of existing farms away from over-congested peri-urban areas. In Thailand there are schemes to encourage good farm practice to gain an approval score to assist in marketing but they are usually voluntary and have only a minor influence on manure management at present (although this could be added in under a green label concept). More generally, there are schemes to encourage farmers to invest in biogas systems – these are primarily to increase energy production but an environmental benefit may also be drawn from the approach.

6. Comparison of the two approaches in Europe and Asia

6.1 *The role of manure management techniques in Europe*

Many European farmers will readily consider introducing equipment or techniques that simplifies the manure spreading operation such as mixers or separators to reduce blockage problems and make handling and transport easier. In some cases, these measures may coincide with a reduced environmental impact such as might be achieved by a more balanced land spreading operation. In a few cases, financial rewards such as a premium price for electricity generated from the anaerobic digestion of organic wastes has encouraged the adoption of treatment technology. Otherwise, where the benefit to the farm operation is less pronounced, the uptake of the related technology is patchy across Europe and reflects more the various pressures brought about by environmental legislation.

The treatment of manure (as opposed to its handling) implies a definite physical or chemical change as the result of a processing option. This may be brought about by physical, chemical, mechanical or biological processes or a combination of these. A wide range of equipment and systems are potentially available in Europe to modify or improve manure (Burton, C.H.; Turner,

C., 2003) but few of these have seen widespread uptake. This is often because they are too costly to install or run, or they are impractical for the farming system or they do not meet the actual requirement. Thus the successful options for manure treatment in Europe fall in one of three categories:

- Composting systems (or related technologies producing a useful solid product)
- Biological systems for liquids that effectively breakdown some of the organic load
- Separation systems that remove solids (clarification) and/or concentrate

Storage, mixing and application systems by themselves do not constitute a treatment although they may be a crucial step in the management of the manure to minimize environmental impact. There is also continuing interest in the use of chemicals or biological additives for various purposes including separation, precipitation, enhancement of biological activity and odour reduction.

6.2 *The future prospects of manure management in Asia*

It seems unlikely that there will be widespread uptake of any manure management technology that implies other than a small cost to a farmer - and even that may only apply if there is sufficient pressure from the implementation of environmental legislation. Otherwise, a farmer will expect a financial return for any investment he makes, even if modest. Schemes that both imply farm expenditure for installation and again for operating will not be well received even if subsidized. Thus it is important to consider the financially viable options that can enable the wider implementation of appropriate technology in the current situation:

- Anaerobic digestion of manure to produce biogas for local use
- Anaerobic digestion with the generation of electricity for farm use and for sale
- Production of composts and other organic products for sale
- Use of manure products to safely fertilise fish ponds (enhanced fish production)
- Use of manure to fertilise arable crops (in place of bought chemical fertiliser)

In the case of compost production, the transport and sale of a standardised and valued product can clearly bring a return to the farmer for an investment in manure management schemes. There is a trade off in the extent of the operation and the value of the product produced: basic schemes for small farms can be expected to produce small amounts of a product of low value for local use. For the larger farmer, the bigger volumes of manure are likely to require transport over longer distances to find adequate markets to take all that produced. The extra transport costs will need to be covered and a higher quality product sold at a higher price would be justified. This in turn would require the inclusion of higher quality adjuncts such as rice straw itself implying a cost both for purchase and transport and the overall increase in the volume of compost produced. In any case, the export of manure products from a farm implies the removal of excess nutrients to be incorporated gainfully in arable agricultural operations.

Using manure in fish production is a widely accepted practice in Asia that provides uptake of some (but not all) of the surplus nutrients. The manure treatment issues are principally those to improve hygiene and possibly to treat run off water to reduce its nitrogen content. Aerobic treatment has some application in supporting fish production (by increasing oxygen availability) and which thus may be directed to simultaneously allowing a degree of water treatment in a modified system configuration. The sludge periodically removed from the pond will be rich in phosphorous and thus potentially a soil improver but with minimal value unless transport is relatively easy.

Organised land spreading of manure and related farm effluents is not well developed in Asia although it offers the most extensive and sustainable long term solution to the problems of animal wastes. Potentially, it can offer some savings to the arable farmer in terms of a reduced purchase of chemical fertiliser if a structured regime is followed. This means a degree of assurance that crop requirements will continue to be met. As a means of disposal, manure effluents can be transported to local farms; fears of disease can be alleviated by AD treatment. However, in any case, little monetary value can be ascribed to such a scheme unless there is some saving in the existing purchase of chemical fertiliser products and even this will not benefit the livestock farmer.

6.3 Mutual lessons for livestock farming in Europe and Asia

A common factor in both Europe and Asia is that governments want sustainable agriculture with a minimal detrimental effect to the environment; however, it is the motivation of farmers themselves that ultimately determines the selection and use of such manure management processes. This will be the result of a balance of (a) what they perceive as benefit, (b) the applied pressures and inducements and (c) the available funds and resources. The perceived benefit is greater in Asia where manure (especially solid materials) are generally valued higher than in Europe. Likewise, compost schemes have a greater chance of success in a region where the cost of chemical fertilisers represents a higher proportion of the operation cost to the arable farmer. It may be thus expected then that the European practice of land spreading ought to then be more readily accepted for the same reason. This might yet be so if two issues are resolved: the first is the fear of compromising arable crop performance both from the point of view of yield and of food safety. European farmers increasingly share this concern and a more concerted attempt is needed to demonstrate targeted use of manures to provide reliably the required nutrients and thus to enable a real saving in bought in fertiliser. Health issues require both attention to an adequate storage and to specify the safer crops for manuring. The use of anaerobic treatment prior to land spreading can impart some reduction of pathogens but it is not sufficient by itself when there are local outbreaks of notifiable diseases. The second barrier to land spreading in Asia is one of transport in a region where roads can be very poor.

In most cases, there is a clear argument to apply some pressure on farmers to encourage a better environmental compliance but a stick *and carrot* approach would be better. In some cases, there is a strong argument for financial assistance especially to accelerate the introduction of new technologies. This would also be the case for community and joint schemes (eg: centralised facilities for biogas production) where the compliance of many partners would be necessary. Codes of good practice by themselves are unlikely to progress far but if compliance was rewarded by a green certification, some motivation would be provided. Such ideas have been around in Europe for some time but the emphasis has been weighed more on the side of food quality; the addition of an environmental credential may be an adequate reward.

Livestock farmers in Europe and Asia differ mostly in the available resources in term of both money and land area. In this respect, some compromise ought to be extended to the poorer farmers in Asia. Schemes must include some financial return that significantly defray the investment and running cost. On the positive side, the greater value given to solid products will continue to ensure that some of the nutrient load is removed from the farm. Where land is lacking, then transport and associations with local arable farmers need to be developed for mutual benefit. In this respect, there is common experience with European farmers.

7. Conclusions

- In both Europe and Asia livestock farming can cause major water and air pollution if the manure is poorly managed. There is a crucial need to bring livestock farming back into balance in terms of nutrient use in order to reduce the environmental impacts otherwise caused. Surplus nitrogen, phosphorous and organic matter must be used, removed or digested if not to contribute to pollution.
- The European model is to spread most liquid and solid manures onto arable land as a source of organic fertiliser for crops. Any practice that might lead to the contamination of surface water is discouraged and penalties are being applied where spillages do occur. Some specific regulations apply on the storage and times and doses for land spreading.
- In industrialised Asia, land is rarely available for manure spreading and transport is frequently a problem. Removal of solid dung is commonplace, the material having a value for fertilising orchards, vegetable production and fish ponds. Schemes that bring a financial reward including composting draw interest but treatment of the dilute effluents produced is rare; disposal is uncontrolled.
- Treatment is an effective option but in the absence of subsidy, it is rarely used because of the implied costs which are already too high for many European farmers. On the other hand, biogas is universally popular and schemes to generate electricity are generally supported. In Asia, biogas itself is still valued for use in the home and in some farm operations.
- There is scope to use land spreading in certain areas of Asia as a means of recycling the nutrients in a joint schemes with arable farmers. In Europe, there is the real need to see the agronomic value of animal manures which amounts to millions of tonnes per year but which, for many farmers, is still viewed only as a waste product.

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