ASSESSMENT OF ENVIRONMENTAL EFFECTS OF AIRBORNE EMISSIONS AND WASTE EFFLUENTS FROM LIVESTOCK PRODUCTION

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SUMMARY

Modern animal production is increasingly regarded as a source of solid, liquid and gaseous emissions which can be both a nuisance and environmentally harmful. Solid and liquid manure contain nitrogen and phosphorus, possibly heavy metals (e.g. zinc, copper) and drug residues which are passed to the environment during grazing or spreading of manure. Aerial pollutants such as odours, gases, dust, micro-organisms and endotoxins (bioaerosols) can compromise the respiratory health of farmers, animals and nearby residents, contribute to soil acidification (ammonia) and global warming (methane) and can travel several 100 m between livestock buildings with the risk of transmitting infectious agents.

Keywords: livestock production, environmental impact, bioaerosols, waste effluents, zinc, copper, antibiotics

INTRODUCTION

Modern animal production is increasingly regarded as a source of solid, liquid and gaseous emissions which can be both a nuisance and environmentally harmful. Solid and liquid manure and waste water contain nitrogen and phophorus which are the most important plant nutrients, but are harmful when applied to agricultural land in excess amounts thereby leading to pollution of ground water by nitrates, surface water with phosphorous (causing eutrophication) and soil with heavy metals such as zinc and copper which are used as growth promoters in the feed stuff. A third group of potentially hazardous effluents are drug residues, such as antibiotics, which may be present in the excreta of farm animals after medical treatment and which are passed to the environment during grazing or spreading of animal manure where they may conceivably contribute to the formation of antibiotic resistance in certain strains of bacteria. The same risk arises when sludge and waste water from sewage plants containing residues of antibiotics and other drugs from human consumption are discharged as fertiliser in the soil and water body.

The most important aerial pollutants are odours, gases, dust, micro-organisms and endotoxins, also called bioaerosols, which are emitted by way of the exhaust air into the environment from buildings and during manure storage, handling and disposal as well as grazing. More than 130 different gaseous compounds have been identified in the air of animal houses, which are a major source of these pollutants.

This paper gives a brief survey on the most important effluents from livestock farming and tries to assess its impact on the environment.

IMPACT OF AIRBORNE EMISSIONS

Aerial pollutants can give cause for concern for several reasons:

Firstly, there is strong epidemiological evidence that the health of farmers working in animal houses may be harmed by regular occupational exposure to air pollutants.

Secondly, an animal's respiratory health may be compromised by these pollutants. In some herds, half of all slaughter pigs may show signs of pneumonia, pleuritis or other respiratory disease. In broilers, about 30% of the birds which are rejected at meat inspection show lung lesions.

The third reason for concern is that aerial pollutants from livestock contribute to soil acidification (ammonia, NH_3) and global warming (e.g. methane, CH_4, nitrous oxide, N_2O). For example, animal production emits about 750,000 t of NH_3 per year in Germany. About 20% of global methane production originates from ruminants. Relative to carbon dioxide (CO_2), the amounts of CH_4 and N_2O in the atmosphere are low, but their global warming potential (GWP) is 21 and 310 times higher than that of CO_2, respectively. The total global emissions are estimated at 535 Tg (CH_4) and 17.7 Tg (N_2O) per year. About 45% of the methane production originates from agriculture, and nearly 20% comes from animal production. N_2O emission from anthropogenic sources is around 8 Tg per year and 6.2 Tg from livestock production. There are substantial uncertainties in all of these estimates because there are large variations in emission rates mainly due to the many influencing factors such as temperature or substrate or keeping conditions. While emission amounts of CH_4 from ruminants are relatively well known there is a considerable lack of knowledge for other species. Similarly, the reliability of the N_2O data is still poor. Animal production systems which use straw seem to release distinct higher amounts of N_2O than those employing liquid manure systems. This may result in conflicts with welfare policies introducing animal friendly and littered keeping systems. It seems necessary to enhance more detailed research in sources and sinks of these gases and that the national and international emission inventories are regularly up-dated in the light of new findings.

Fourthly, particulate emissions, such as dust and microorganisms, from livestock buildings may be a source of complaint from people living in the vicinity of livestock farms. The travel distance of viable bacteria from animal houses via the air is presently found several 100 m downwind of animal buildings; *Mycoplasma* species may travel at least 400 m. From epidemiological modelling it is known that the virus causing Mouth and Foot Disease can be transmitted over more than 75 km while in an airborne state. In a recent field study about 4000 cfu/m³ of staphylococcae were found nearly 500 m downwind a broiler barn (Schulz 2007) as shown in Figure 1. There is a need for dispersion models for particulate pollutants in animal farming.

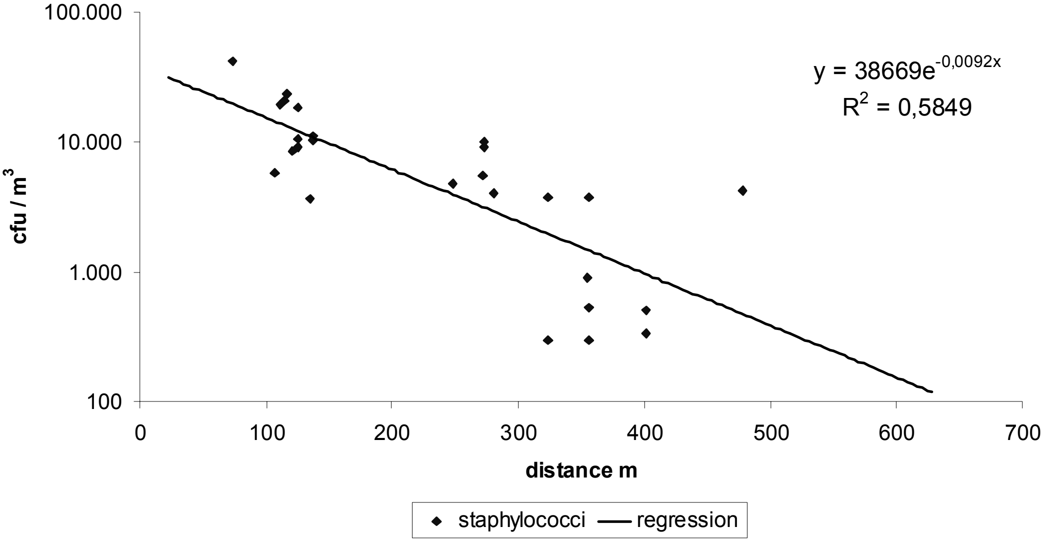

Figure 1. Decreasing concentration of airborne staphylococci in prevailing wind direction with increasing distance to the emitting broiler barn with forced ventilation at outdoor wind velocities between 1,7 and 6,3 m/s. n=26

ANTIBIOTIC RESIDUES

Little is known about the occurrence, the fate and possible effects of drugs in the environment (Kümmerer 2001, Daughton 1999). With a special focus on drugs used in human medicine, it has been established that these compounds mainly reach our surface waters via the effluents of sewage treatment plants. Today, up to 80 compounds have been identified and quantified in the low ppt to ppb ranges (Heberer 2002). Studies performed in the UK, Denmark, Germany, and the US revealed, that these agents represent a new class of organic environmental contaminants worldwide. Effects discussed by the entry of these compounds into the aquatic environment may be the spread of antibiotic resistance or effects on the endocrine system because of the hormonally nature of some of these compounds (Daughton 1999).

Only few routes have been identified so far for the entry of veterinary drugs into the environment. Recently tetracyclines in farmland in concentrations up to 300 µg/kg were found using sophisticated analytical LC-MS-MS techniques. It demonstrates that these antibiotics are persistent and can accumulate in soil after repeated fertilizations with liquid manure. Leaching of these compounds into deeper soil segments or into groundwater depends on the sorption capacity of the drugs in the first 30–40 cm of soil (Hamscher 2000 and 2002). Only limited information exists also on effects of these drugs onto the soil microorganisms. Because the soil microorganism community is a very complex system with at least 95% of unknown bacteria living in this compartment, investigations on this field are hardly to perform.

Tetracyclines and several other veterinary drugs (e.g. various sulfonamides, tylosin) are used in huge amounts not only within the EU (Anonnymus 2001) but also in the US (Kolpin 2002) and in China, Southeast Asia and Russia. They are or have been used for many years as feed additives, for prophylactic, metaphylactic, and for therapeutic purposes. Usually, the drugs are applied via the animal feed. In intense pig production all these drugs are used and especially this production system has been known for many years as an emitting source for dust (Hartung 1997 and 1998) with the result, that this high dust exposure in animal confinement buildings has been considered as a respiratory health hazard (Nowack 1998, Iversen 2000). Recent investigations show that dust in piggeries can contain various antibiotics including tetracyclines, sulfonamides, tylosin and chloramphenicol (Hamscher et al. 2003). This indicates a new entrance route for veterinary drugs into the environment. Adverse effects on animal and human health resulting from the exposure to dust highly contaminated with antibiotics cannot be excluded and should be taken into consideration in future research.

IMPACT OF SOLID AND LIQUID EFFLUENTS

The substances which are detrimental to soil and water are those found in animal excrement containing nitrogen (N) and phosphorus (P, as phosphates). In addition there can be residues in feed, such as zinc, copper or antibiotics. Nitrogen and phosphates are important plant nutrients, which if applied properly can be used in commercial fertilizers with no adverse effects on the environment. These substances constitute a danger only if they are applied in too high amounts and at times outside the growing season. Nitrate can migrate through the soil in the groundwater. Nitrate-enriched drinking water can induce cyanosis, particularly in infants, and is suspected of having a role in stomach cancer. Nitrates and phosphates can also accumulate in surface water due to over-fertilization with liquid or solid manure or via rainwater runoff from freshly fertilized fields, and cause eutrophication of natural bodies of water. The feces of one pig corresponds to ca. three human-equivalent-units (HEU), which means that a body of water contaminated with these substances must have the regenerative power to process the equivalent of ca. 350 liters of sewage from humans (which produce ca. 120 l waste water/person/day).

The use of zinc (Zn) and copper (Cu) in piglet feed has increased recently, as they serve as trace elements necessary for a number of biological functions. At higher dosages they also have pharmacological effects and can prevent diarrhea and generally increase productivity. At present the annual transfer of zinc and copper from pig slurry onto agricultural areas comprises ca. 0.8 kg Zn and 0.4 kg Cu per hectare. This is four times the amount extracted in crop harvest for zinc and up to 20 times that for copper. It is vital that the input of these heavy metals does not exceed the amount extracted, as they will otherwise accumulate in soil and plants. Excessive intake of Zn and Cu can lead to serious poisoning in animals.

Under the existing legal fertilizer regulation, in the application of waste from animal production and of sewage sludge the nitrogen, phosphorus, zinc and copper input must not be greater than the amount withdrawn. Such balanced fertilization has been practiced with more and more success in recent years, as application of fertilizers must be preceded by analysis of the soil and of the substances to be applied.

SYNOPSIS OF ENVIRONMENTAL EFFECTS OF POLLUTANTS FROM LIVESTOCK SOURCES

Table 1 summarizes our present knowledge of the impact of emissions from livestock farming on farm livestock and man and the distance over which the emissions may have effects. Besides effects on animal and man local, regional and global impacts are characterised. Odours are relevant closer to animal houses only. Ammonia can act directly on needles and leaves of trees close to sources where high amounts are released. It also causes damage in the far environment by over fertilizing soils and water and contributes to the decay of forests (via acid rain). Indoors, ammonia is an irritant for the respiratory tract of man and animal. Hydrogen sulphide is noticed as a prominent odorous compound outside animal houses. Occasionally indoors it can be fatal to animals and man at very high concentrations after the release of high amounts, e.g. when old liquid manure is agitated. Methane and nitrous oxide contribute to the greenhouse effect, but do not cause significant problems indoors. Little is known about the fate of dust, microorganisms and endotoxins outside livestock buildings, although there is some concern that these compounds may cause a nuisance to the population living in the vicinity of animal enterprises, particularly in areas with high animal densities. Nitrate and its product nitrite can cause pollution of ground and drinking water. The effects are local and the impact on human health is low. Together with phosphate both nutrients can enhance eutrophication of surface waters. Zinc and copper, which are increasingly used as growth promoters instead of antibiotics in animal feed, are accumulating e.g. in pig liver and locally in soils and plants that then cause health problems in grazing sheep. Not much is known about the fate of veterinary drugs such as antibiotics in the environment which are excreted with the faeces. There is some concern that they may contribute to the development of drug resistance in bacteria.

Table 1. Environmental impact from livestock sources

Compound	Impact on People	Impact on livestock	Impact on ecosystems	Local	Regional	Global
Odour	nuisance	no	no	yes	(yes)	no
Ammonia NH_3 (irritant)	indoors high	indoors high	high	high	yes	low
Hydrogen sulphide H_2S	toxic indoors	toxic indoors	no	odour	?	?
Methane CH_4	no	no	global	no	(no)	yes
Nitrous oxide N_2O	no	no	global	low	low	yes
Dust/PM10	resp. health allergy		low	yes	yes	?
Bacteria/Virus	infections	infections	no	yes	yes?	no
Endotoxin	yes	yes	no	yes	(yes)	no
Nitrate in drink. water	yes low	eutroph.	yes	yes	yes	
Phosphate	no	no	eutroph.	yes	yes	yes
Copper/Zinc	low (pig liver)	yes (sheep)	yes (soil)	yes	yes	yes
Vet drugs	resistance?	resistance?	?	?	?	?

CONCLUSIONS

- Livestock farming causes significant emissions such as nitrate, phosphate, heavy metals and also antibiotics in manure and liquid effluents as well as odour, gases, dusts, microoganisms and endotoxins in the exhaust air from animal houses, from manure storage facilities, during application of manure and during grazing.
- These effluents can have distinct impacts on air, water, soil, biodiversity in plants, forest decay and also on animal and man.
- There are indoor health effects on man and livestock (ammonia, hydrogen sulphide, bioaerosols) and impacts on the local, regional and global environment.

- Odour, bioaerosols, ammonia, nitrogen, phosphorous and heavy metals may either have a local or a regional impact. Gases such as methane and nitrous oxide contribute to global warming.
- There is equally a lack of knowledge on the airborne transmission of infectious agents such as virus and microorganisms between farms.
- Little is known on the role of drugs such as antibiotics in the environment. There is concern that these residues may contribute to the development of bacterial resistance.
- Local and regional environmental problems are enhanced by high animal densities, insufficient distances between farms and to residential areas.

RECOMMENDATIONS

1. Adequate and efficient feeding regimes are required with minimal wastage of nitrogen and phosphorous and limited use of growth promoters.
2. The development of low emission production systems should be encouraged including mitigation techniques, e.g. biofilters, bioscrubbers, covered manure pits and shallow manure application.
3. The administration of drugs has to be restricted to the treatment of diseases only. The fate of the drugs in the environment has to be investigated.
4. There is an urgent need to establish safe distances between farms and to residential areas to prevent transmission of harmful substances. This should become an essential part of local and regional planning.
5. Environmental standards for animal production should be established and applied to all European countries.
6. A systematic environmental risk analysis is required to compare different production systems and different regions worldwide.
7. For the realization of these aims the cooperation of farmers, agricultural engineers, veterinarians and governmental agencies is necessary.

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