RURAL INDUSTRIES RESEARCH
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# Travel Report: Professor Jorg Hartung Environmental and Welfare Issues for the Egg Industry

**A report for the Rural Industries Research and Development Corporation**

By

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# Introduction

Prof Hartung (Dr. med. vet. Dr. med. vet. habil.) is an international expert on the housing, hygiene and welfare of intensively housed animals. He has particular expertise in the areas of hygiene and air quality in pig and poultry sheds and has pioneered the development of assays to measure components of viable and non-viable micro-organisms found in the airspace of sheds. These include endotoxins, β-glucans and peptydogylcans. During his visit he was able to review the currently funded RIRDC projects that involve air quality and pollutant monitoring. He is also regarded as an expert in the field of animal welfare and while in Australia he spoke to both Poultry Producers and students on animal welfare in the poultry industry.

Professor Hartung is currently the Director of the Institute of Animal Hygiene and Animal Welfare in the School of Veterinary Medicine Hannover, Germany. He is a previous Chairman of the VDI Guideline Groups 3471/4 on emission control in pig and poultry production in Europe and was head of "the Environment Group" of the "Welfare Science Division", at Silsoe Research Institute (Bedfordshire UK), from 1991 to 1993.

He is a member of the Scientific Committee for Animal Health and Animal Welfare of the EU Commission and Chairman of the German Federal Committee for Animal Welfare. He is also a member of the Federal Committee for *"Biological Risks at the Workplace",* established by the German Ministry of Labour and Social Affairs.

He is involved in teaching Animal Husbandry and Animal Production to veterinary students. The course includes ecological aspects of animal production, as well as ventilation and air quality in animal housing. He is also the convenor of a special course on the "Special problems of animal husbandry/hygiene" for final year veterinary students.

Professor Hartung is the Chief editor of Deutsche tierärztliche Wochenschrift (DTW), the well respected German Veterinary Journal. He is also a reviewer for several other journals including Occupational and Environmental Medicine (OEM), the Journal of Agricultural Engineering Research (JAER) and Annals of Agriculture and Environmental Medicine (AAEM).

# The European situation regarding intensive animal production

Consumers in the UK and Europe have a great deal of influence over agricultural policy, particularly with regard to food safety, animal welfare and protection of the environment.

In the European Union, governments have responded to consumer pressure to regulate such areas as antibiotic usage, intensive animal housing, including the availability of bedding and spray cooling, as well as strict regulations with regard to effluent production and disposal.

The continent of Europe is roughly the size of Australia, with an enormous diversity of culture and prosperity. Involvement in poultry production is just as variable, with some countries having a tradition of strong involvement, while others have only recently become major producers for Western Europe.

Professor Hartung sees three major issues facing the European poultry industry:

1. Public perception of the industry and its structure
2. Environmental pollution and odour
3. Animal welfare

## Public perception of the industry and its structure

Although it varies between countries, there is generally a poor understanding of rural production among the urbanised populations. This is typical of developed countries including Australia, where the relationship between producers and consumers has become distant.

European consumers worry greatly about emerging livestock diseases such as BSE (‘Mad Cow’) and FMD, and are concerned by the intensity and size of pig and poultry production. Because of their size, large units are perceived as animal factories, rather than animal farms. As a result, Germany’s pig and poultry trade actively promotes the use of the word ‘farming’ over ‘production’, in order to minimise their industrial image in the eyes of the public.

The German government firmly regulates poultry production in areas of taxation, building regulations, and health standards for the keeping and transport of stock and the rendering of by-product. Other laws apply to feed composition, effluent application and air pollution.

The European Union (EU) in Brussels has been greatly influenced by concern over behavioural disorders among intensively housed animals, and has produced guidelines to apply to EU member countries. The guidelines will apply to all new, extended or refurbished poultry farms from January 1st 2002, and will apply to every farm from January 1st 2012.

## Environmental pollution

With Europe's comparatively high human and pig and poultry densities, pollution is a major concern. Germany alone produces around 250 million tonnes of animal effluent every year.

Soil application of animal waste can result in excessive nitrate and phosphate levels. Any antibiotic residues present in manure can also affect soil micro-organisms, killing some while helping others to develop antibiotic resistance.

However, the most immediate and biggest problem is the acidification of soils. This occurs when ammonia reacts with other air pollutants such as sulphur dioxide, which is a product of many European power generating plants.

In some areas, 75kg/ha/year of nitrogen may be deposited from the atmosphere, which is enough to eliminate many plant species with low nitrogen tolerance. European animal farming releases 750,000 tonnes of nitrogen into the atmosphere every year, and subsequent acidification is thought to be responsible for 30% of Europe's annual forest destruction.

Regulations governing nitrogen loss and effluent application are now in force:

- Land application is limited to 170 kg/ha/year, and sites must be evaluated for their suitability to effluent spreading.
- Storage of slurry: No more than 10% nitrogen loss during storage.
- Application of slurry: No more than 20% loss, and application can only take place between November and February.
- Storage of solids: No more than 25% loss during storage.
- Application of solids: No more than 20% loss, and application can only take place between November and February.

## Animal welfare

The satisfaction of public concern has added several aspects to existing welfare guidelines, as covered in the EU Guidelines mentioned earlier. The German government has gone a step further and produced a video describing the recommended practices involved in pig and poultry farming.

There is need also to reconsider how we describe our industry. The term production usually refers to mechanical production systems and re-enforces the perception of factory farming. In Europe the terms poultry farming and pig farming are being promoted and used to counter the negative image of the term "pig and poultry production".

Some producers took the decision to take their flocks outdoors, which is the public's ideal version of welfare-friendly poultry farming. However, outdoor production in Europe has its problems:

- Parasites are much more difficult to control.
- Predators may also be a problem.
- Leg injuries have also increased.

# The future

EU consumers now demand sustainability in livestock production. To achieve this and remain profitable, producers must incorporate four vital production aspects:

- welfare (bird and human) – the public must be satisfied with worker and animal conditions.
- economy – the price paid by consumers must be acceptable and compare well with alternative products.
- ecology – the environment must not suffer unduly from poultry farming.
- food security/quality – the public must be able to trust and enjoy the product.

Failure in any of these areas will result in consumer backlash. In Europe this has already been seen in the beef industry, particularly in the UK, where consumers reacted to a possible connection between Mad Cow disease and Creutzfeldt Jakob Disease (CJD) by refusing to eat beef.

Australia's isolation and distance have helped us avoid many of the livestock problems of other countries, but that is no reason to relax our guard. Our intensive production does not have quite the same environmental problems, mainly due to our lower animal density, but they are emerging. Welfare concerns are not as obvious as in Europe, but there is no reason to suppose that they will remain that way, bearing in mind our highly urbanised population. It is up to our industries to predict consumer concerns and act upon them, in much the same way as the pig and poultry industries have been pro-active in the areas quality assurance, and the pig industry has worked to reduce odour and emmissions.

We need to learn from the experiences of our overseas farming colleagues, if our industries are to survive and remain prosperous.

# Meetings

SA Pig Producers - 9th of May, the Roseworthy Campus
The Australain and NZ Clean Air Society – 10th May, the Thebarton Campus
Animal Science Student -10th May, the Roseworthy Campus
Animal Science Seminar Series – 11th May, the Roseworthy Campus
Australian Association of Pig Veterinarians – 14th to 16th May, Melbourne
SA Poultry Egg Industry and SA Broiler Industry – 18th May, the Roseworthy Campus

# Attachments

1. Egg production in Europe and Germany - Jörg Hartung
2. Apects of welfare in the egg industry - Jörg Hartung
3. Hygiene and OH&S issues associated with poultry farming in Germany - Jörg Hartung

# REDUCTION EFFICIENCY OF A CONTAINER-BASED BIOFILTER FOR BIOAEROSOLS FROM A BROILER HOUSE

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## SUMMARY
Biofiltration is known as a method to abate odour pollution from agricultural and industrial sources. In recent years there is an increasing interest in reducing or removing further pollutants such as dust particles and micro-organisms (bioaerosols) from the exhaust air of farm animal buildings. An orientating study was performed to investigate the efficiency of a combined scrubber/biofilter unit to remove boiaerosols from the exhaust air of a broiler house with about 20,000 birds. Samples were taken in the animal house air, from the air stream inside the biofilter after the second scrubber and from the cleaned air above the biofilter bed. Minimum reduction efficiencies were calculated for airborne dust particles, total bacteria and fungi as 83, 90 and 73%, respectively. Similar reduction efficiencies were grossly seen for endotoxins too, but many of the results showed considerable variations which probably were due to cumulative and enrichment effects in the aerosolised scrubber water of the biofilter. The results show that the investigated biofilter system is able to reduce the amount of airborne particulates in the exhaust air of the broiler barn significantly. Future work is needed to specify kind and number of those micro-organisms which are released into the environment by passing the biofilter. This is necessary from the point of view of occupational and environmental hygiene.

Keywords: biofilter, bioaerosols, reduction efficiency, broiler

## INTRODUCTION
The air in livestock buildings contains gases, odours, dust particles and micro-organisms which are emitted by the ventilation system into the environment. It is known that odour emissions can be a severe nuisance for near-by living residents. Therefore administrative procedures are in place when new farms are licensed either to establish sufficiently large distances between residential area and the emitting farms or to enforce abatement techniques to minimise odour emissions. One of the appropriate methods which is already approved in practice for odour reduction is the biofilter technique. The polluted exhaust air from the animal house is forced to pass a filter bed which usually consists of brushwood, bark, compost material or similar organic stuff. The break down of the odorous compounds is performed by micro-organisms which are naturally present colonising massively the surfaces of the filter bed materials. The activity of this mixture of bacteria can be supported when the scrubber water is inoculated with a specimen of fresh sewage sludge. The efficiency of biofilters mainly depends on the activity of the micro-organisms, the nature and concentration of the pollutants which should be reduced and the operational status and maintenance of the bedding material. Odour reductions in ventilation air from livestock buildings between 41% (Siemers and van den Weghe 1997) and 99% (Holste and Mannebeck 1997) are reported.

Little is known on the role of the emitted particles in the surrounding of the farms. There is increasing concern in recent years that emitted airborne dust, dust borne components and micro-organisms may play a role in respiratory affections in people living in the vicinity of animal enterprises. Measures to reduce particulate emissions from animal houses are not yet well investigated. Orientating tests with biofilters showed that the dust mass in the exhaust air of piggeries can be reduced by up to 85% (Siemers and van den Weghe 1997). Martens *et al.* (2001) forum a reduction potential for bacteria in half technical scale biofilter units between 70 and 95%, while much less reductions of only 11% were observed in a commercially operated biofilter at a pig house (Seedorf and Hartung 1999). These inconclusive results are probably due to the different constructions of the biofilters which can vary between simple filter beds and filter/scrubber combinations. Another reason may be the use of different sampling techniques (time, place, duration, medium etc.) and analysis procedures for the various compounds. The development of standardised techniques and procedures would be advantageous in future.

This paper reports on the reduction efficiencies of a newly designed container based biofilter with two scrubber steps and a biofilter bed for airborne particulates such as dust, bacteria and fungi using a standard glass impinger for sampling both micro-organisms and particles.

## MATERIALS AND METHODS

*Broiler house and biofilter.* The investigations were carried out in a conventional broiler house with straw as letter material. The number of animals varied between 22,000 at the beginning and 16,000 at the end of the measuring campaign after 44 days. At days 30 to 33 about 6,000 bigger birds were caught and brought to slaughter. The forced ventilated building was equipped with fans on the rear side and auxiliary fans in the ceiling providing additional ventilation capacity for hot summer conditions. The main air stream was moved by the rear fans and passed horizontally through an attached biofilter container. The biofilter unit itself contains three compartments to reduce odour, gases and dust. The first two stages of the system are scrubbers to wash out water soluble and solid components, i.e. ammonia and dust, from the polluted livestock air (pre-attached scrubber unit). The washing water is recirculated, spilled and evaporated water is replaced by fresh water automatically. The third cleaning stage is the virtual biofilter where the particles not yet eliminated by the scrubber should be retained in the filter bed. The bed consisted of a frame of stainless steel bars filled with bark and coarse wood chips. The area of the filter was 16 $m^2$.

*Sampling Procedure.* Dust particles, bacteria, fungi and endotoxins were sampled at three positions. One sampling position was within the broiler house, one behind the second scrubber unit and the third above the biofilter bed, shielded by a plastic barrel to avoid atmospheric influences. The barrel was equipped with a chimney-like integrated funnel for the air outlet causing a slight over-pressure within the barrel to prevent uncontrolled influx of atmospheric air at the point of contact between the barrel edge and the rough structured surface material of the biofilter bed. Samplings were carried out at six days between June and October. At each sampling day 3 samplings with three replicates were taken, 54 samples in total. The samples ere taken with all Glass Impinger 30 (AGI-30) systems. The air was sucked through the impingers for 20 minutes with a flow rate of 10.5 1 $min^{-1}$. Each impinger was filled with 50ml sterile isotonic NaC1 solution. The sampling height was 1.5m above ground. Figure 1 shows a rough scheme of the biofilter/scrubber system and the position of the sampling points.

*Analysis*. The saline impinger solutions were investigated for mesophilic total bacteria, mesophilic fungi, endotoxins and suspended particles. The bacteria were grown on blood agar (incubation temperature 36°C) and the fungi on DG 18 agar (incubation temperature 25°C), respectively. The reading are given in colony forming units (CFU) per $m^3$ of air. Endotoxins were determined with the Limulus-Amoebocyte-Lysat (LAL) test and quantified photometrically by the chromogenic-kinetic method. The results are given in endotoxin units (EU) per $m^3$, where 8 EU are approximately proportional to 1 ng. The number of suspended particles in the Impinger solution was counted with an optical particle counter (Abakus, Klotz, Unterhaugstett, Germany) which is able to detect particle sizes in the range between 0.7 µm and 120µm. The results are expressed as number of particles (n) per $m^3$ air.

*Data processing.* Assuming that the volume flow of the waste gas in not negatively influenced by the design of the filter system or the sampling technique the reduction efficiency $\eta_B$ (%) can be calculated from the corresponding concentrations at the three sampling points for the different pollutants as follows:

$$\eta_B = \frac{C_{B,\,crude} - C_{B,\,clean}}{C_{B,\,crude}} \bullet 100$$

Where C is the bioaerosol concentration (particle, bacteria, fungi, endotoxins) in the crude gas and in clean gas I and II. The difference $\eta_B$ between crude and clean gas II is the total reduction efficiency. Negative $\eta_B$ are indicating an increase of airborne components in the clean gas.

## RESULTS

The indoor concentrations of particles (P), total bacteria (B), mesophilic fungi (F) and endotoxins (etox) ranged between 2.26 x $10^6$ to 11.9 x $10^6$ n $m^{-3}$, 1.04 x $10^6$ to 14.9 x $10^6$ CFU $m^{-3}$, 2.15 x $10^3$ to 104.5 x$10^3$ CFU $m^{-3}$ and 10.3 to 216.6 EU $m^{-3}$, respectively. In Table 1 the calculated reduction efficiencies between the crude gas and the air behind the second scrubber (difference between sampling point 1 and 2) and between the crude gas and the clean gas (1-3) are shown. The concentrations in the clean gas were distinctly lower in most cases. The average reduction efficiencies for particles were between 83.1 and 97.2%. Usually the filter (step 3) clearly increased the reduction efficiency. Only at day one the reduction efficiency dropped slightly by approximately 2% between sampling point 2 and 3. The lowest reduction efficiency for total bacteria (B) was 87.5%, the highest 99.1% (day 2). The reduction efficiencies for mesophilic fungi (F) were between 73.1% and 97.9%, with one exception. At day six more airborne fungi were found in the scrubber unit (sampling point 2) than in the air of the broiler house ($\eta_B$: -88.7%). The reduction efficiency of the container based biofilter for Endotoxins (Etox) differs considerably. The best $\eta_B$ was calculated with 92.9%, but on day 6 an increase of nearly 180% of endotoxins in the clean gas II was observed. At days 3, 5 and 6 higher Etox concentrations are observed in the cleaned gas behind second scrubber than in the animal house. The highest enrichment was seen at day 5 with 11300%.

**Table 1. Reduction efficiencies $\eta_B$ (%) of the biofilter compartments 1, 2 and 3 for selected bioaerosol components (for 1, 2 and 3 see figure 1).**

| | 1-2 | 1-3 | 1-2 | 1-3 | 1-2 | 1-3 | 1-2 | 1-3 | 1-2 | 1-3 | 1-2 | 1-3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day: | 1 | 1 | 2 | 2 | 3 | 3 | 4 | 4 | 5 | 5 | 6 | 6 |
| P | 85,7 | 83,8 | 80,1 | 97,2 | 82,8 | 92,2 | 57,4 | 93,0 | 52,3 | 95,1 | 78,4 | 83,1 |
| B | 86,7 | 98,3 | 90,5 | 99,1 | 53,6 | 94,5 | 74,1 | 96,9 | 65,8 | 95,4 | 19,1 | 89,9 |
| F | 68,5 | 97,9 | 13,4 | 73,1 | 49,5 | 85,6 | 17,5 | 74,9 | 58,8 | 95,2 | **-88,7** | 76,7 |
| Etox | 44,7 | n.c | 83,6 | n.c | **-103,0** | 81,2 | 38,7 | 92,9 | **-11229,3** | 80,5 | **-3600,8** | **-180,9** |

n.c not calculated due to missing values

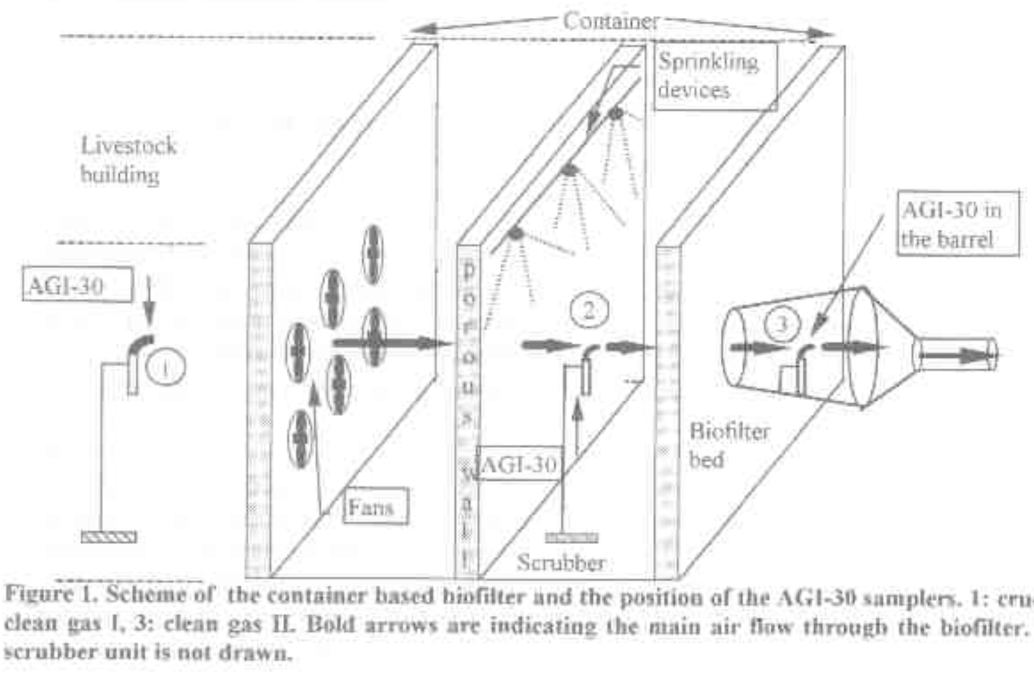


**Figure 1. Scheme of the container based biofilter and the position of the AGI-30 samplers. 1: crude gas, 2: clean gas I, 3: clean gas II. Bold arrows are indicating the main air flow through the biofilter. The first scrubber unit is not drawn.**

## DISCUSSION

Biofiltration is one technical option to remove volatile and particulate pollutants from waste gases in gases like ammonia in the exhaust ventilation air of livestock buildings. In recent years since concerns are rising in the residential areas around livestock enterprises about possible health effects caused by emitted particles and micro-organisms interest grows to use biofilters in or at animal houses as an abatement technique for these bioaerosols. First investigations revealed inconclusive results. Some filters worked with high others with low cleaning efficiencies. The presented study demonstrates considerable differences in reduction efficiency between sampling days in the same plant. The stability and efficiency of biofilter systems seem to depend on a variety of factors and conditions such as livestock type, animal density and ventilation rate, design of the biofilter, the management of the system, the quality and maintenance of the filter bed material as well as the temperature and moisture in the filter bed. A critical point is the organic biofilter material which is poorly defined. The structure and type of bedding can vary between batches in the same plant ant between different plants. It can also deteriorate with time which may change its retention capacities for various compounds. Bedding material usually contains more than $10^7$ germs per gram which colonising the surfaces of the material. They are necessary to remove e.g. odours. The permanent air flow through the biofilter can mobilise some of these attached micro-organisms as demonstrated for fungi by Rabe and Becker (2000). In extreme situations emission quantities may be higher than without a biofilter. From investigations on biofilter surfaces in composting plants it is known that the clean gas can contain two times higher concentrations of fungi than were found in the crude gas before the filter (Seedorf 2000).

In this study slight enrichment processes were observed for particles at sampling day one between sampling point 2 and sampling point 3 when the total reduction efficiency decreased by 2%. The additional particles are probably released from the wooden biofilter bed. An enrichment of compounds can occur in the scrubber unit. In the washing water which retains water soluble substances and dust particles is re-circulated accumulating large amounts of compounds. If the sampling capacity of the liquid is exceeded compounds can break through and carry on to the biofilter. This may have happened with the endotoxins at sampling says 3 and 5. If the compounds are not kept back by the biofilter they appear in the “clean gas” (sampling day 6). The example of sampling day 5 shows that good adsorption properties of the filter bed may compensate overloading of the scrubber step for some time mechanism seemed to work for fungi at day six.

The results of this investigation show that a repeated and regular monitoring of biofilter systems is necessary to recognise mis-functions and leaks. Because of the complexity of factors which can influence the total reduction efficiency a deeper understanding of the different technical and biological steps in the cleaning process are desirable. The presented method is relatively simple to perform and covers the most important pollutants which may cause harm in the residential surrounding of farms. For new biofilter/scrubber systems it seems useful to introduce a monitor procedure which covers typical and extreme operational situations as well as various weather and climatic conditions.

Furthermore it is desirable to define specific bacteria and fungi which are related to health hazards and which may serve as marker substances. However, the investigations should not only focus on micro-organisms which pass a biofilter, occupational health aspects should also be regarded because the biofilter operations need maintenance and service periods where people are working directly in and with the system and are exposed to all of the more or less enriched compounds.

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