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Odour management options for meat chicken farms

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POULTRY CONFLICT

Existing meat chicken farms were traditionally located in urban fringe areas due to the proximity of processing plants and markets (McGahan et al. 2002). Over the last decade the combined effects of urban and rural residential expansion, increased environmental awareness, significant growth in meat chicken consumption, the need for individual farms to expand to remain competitive, and the absence of effective planning strategies or controls have increased the risk of conflict.

Increasing land prices limit the capacity of existing poultry farms to acquire additional buffer areas and the substantial investment in existing infrastructure inhibits relocation. Careful identification and management of environmental and amenity concerns, particularly odour, is vital for the sustainability of individual farms and the current industry.

This Agnote summarises the factors contributing to odour from meat chicken farms, and details farming practices and technologies for reducing the potential impacts. Whether odours are perceived as offensive, however, also depends on complex distribution factors and perceptions.

Additional information on best practices is provided in the NSW Meat Chicken Guidelines currently being finalised. The development of an Environmental Management Plan for the farm can also help identify and document relevant actions.

MEAT CHICKEN PRODUCTION AND ODOUR GENERATION WITHIN SHEDS

Chickens for meat production (broilers) are placed within sheds on meat chicken farms as day-old chicks on a bed of dry organic litter (e.g. sawdust, planner shavings, rice hulls). During the subsequent weeks the birds grow rapidly and the amount of manure they excrete increases. The bedding litter (including manure, dust and feathers) begins to break down, creating odorous compounds which then volatilise. The atmospheric emissions that result can create a source of conflict if houses or community facilities are located within the affected area.

Bird density (kg per square metre), shed temperatures and odours peak at around 5 to 6 weeks, at which stage a proportion of the birds are removed ('thinned'). The odour intensity is maintained while the remainder continue to grow until final harvest at around 6 to 8 weeks. A short break typically follows during which the used litter is removed, the sheds are thoroughly cleaned and fresh litter is put in place before a new batch starts. Most complaints relate to the end of the cycle or to the clean-out of litter but odour has been reported as a significant nuisance as early as 3 weeks into the cycle.

The factors contributing to odour generation from poultry sheds are complex. While the dominant odorous compounds are ammonia, hydrogen sulfide and mercaptans, some 75 compounds have been recognised within meat chicken sheds (Jiang & Sands 2000, McPherson 2000). Some compounds (e.g. sulfides) are more readily detected by humans than others or are perceived as more offensive even in low concentrations. The combination of compounds may also mask certain odours or create an odour that is greater than the sum of the individual components (McPherson 2000). Additionally, perceptions of

an odour's acceptability and individual capacity to detect particular odours can vary greatly.

The type of compounds produced within meat chicken sheds and their concentration is influenced by the nature and rate of biodegradation within the litter (McGahan et al. 2002). High litter moisture content, low oxygen levels, small particle size, high temperatures and low pH encourage anaerobic bacterial activity and the generation of odours. The rate at which the compounds subsequently volatise is influenced by litter pH and temperature, ventilation rates and climate.

Control of the factors summarised in Table 1 is therefore important for reducing odour levels and the potential for conflict.

Table 1. Factors affecting odour generation in meat chicken sheds

Process	Affecting factors
Breath, flatus and faeces	Bird number, health and diet
Degradation of litter	Temperature, pH and water content in the litter
Volatilisation of odour compounds	Ventilation rate, climate, litter pH and temperature

From McGahan et al. 2002

ODOUR CONTROL PRINCIPLES

Resolving conflict is difficult and costly. Preventative actions include minimising the number of people that may be affected by appropriate site selection and shed orientation (including fan direction), purchasing additional buffer lands, or using effective land use planning controls to prevent encroachment. Where such options are no longer relevant, the most effective strategy is to manage odour-generating processes at the source and maintain positive communication with neighbours.

Odour impacts can also be reduced by dispersing (diluting) odours before they reach potential receivers. How well this works depends on the relative separation distance and the number and direction of sensitive receivers. The frequency, intensity, duration and offensiveness of the odours are also critical.

Odour controls at the receiver are rarely viable and only warrant consideration where all other approaches remain ineffective. For example, installing air conditioning in odour-affected houses does not control odour outside the treated building and is expensive if there are multiple houses to treat.

COMMUNICATION

Even on well-managed poultry farms, odour will be generated. Keeping in touch with neighbours can reduce the risk of conflict by helping them understand the poultry production process, the steps being taken to reduce potential problems and practical limitations.

Open communication channels also allow feedback and provide an opportunity to reduce odour, noise or dust problems before significant conflict occurs. Relatively minor adjustments to the timing of shed clean-outs, litter-spreading, management standards or vehicle movements may be all that's necessary. It may be possible to also avoid the coincidence of peak odour risk periods or activities with special social events planned for a neighbouring property by mutually adjusting either the timing of poultry operations or the event.

Meat chicken farms in proximity to existing residences are encouraged to maintain a daily log of weather conditions (prevailing wind direction and strength, temperature) and farm activities to assess the cause of any reported conflict incident more accurately. This is particularly important where there might be many odour sources or an existing history of conflict. If future expansions are proposed, complaints and activity logs can also demonstrate the effectiveness of current management practices in avoiding conflict.

MINIMISING ODOUR AT THE SOURCE

Good design and management practices are the keys to minimising odour from meat chicken sheds and for improving production (McGahan et al. 2002). Therefore, assessing current practices and shed features should be the first step in an odour-reduction program.

The critical factors influencing odour generation are temperature, humidity, ventilation and the management of litter. Appropriate management of stocking rates, diet and waste products may also be relevant as outlined in the following sections. Where feasible, the number of birds should also correlate with the available separation distances. Further information for calculating this is provided in the 'Technical Notes' for the draft EPA odour policy: http://www.epa.nsw.gov.au/air/odour.htm

1. Shed temperature and humidity

Temperature influences the degradation of litter and the volatilisation of odorous compounds. Maintaining temperatures near to 22° C is also critical for bird welfare and production – healthy birds will produce drier and less odorous manure.

Strategies to save energy, reduce radiant heat and increase the cooling capacity of airflow within poultry sheds include:

- aligning the sheds along an east–west axis with large roof overhangs and shading ventilation openings to minimise exposure to direct solar radiation
- providing adequate roof (and wall) insulation
- maintaining mown grass cover or other vegetation around sheds to reduce ground radiation
- using effective cooling systems and ensuring ventilation openings and fans are free from obstruction
- keeping birds calm to minimise heat production: darkened sheds and green lighting can help do this
- in summer, reducing bird density if temperatures cannot be maintained.

2. Adequate shed ventilation

Effective air exchange within the shed helps reduce shed temperatures and encourages optimal litter moisture levels by promoting bird health, reducing the need for fogging and increasing drying rates. Good ventilation also dilutes the concentration of odorous gases released to the outside air (McGahan et al. 2002).

Ventilation design should optimise bird comfort by taking into account the climate and stocking densities. The type of ventilation system may also influence the dispersal of odours in the landscape. Conventional sheds with side openings and internal stirring fans are more subject to local wind patterns than tunnel-ventilated sheds, where the air is basically exhausted in one direction.

When planning a new or expanded meat chicken farm, the risk of odour problems can be reduced by exhausting air away from the direction of prevailing winds, cold air drainage pathways, local residences or community facilities such as halls or sports grounds.

Odour can also be reduced by maintaining ventilation systems. Regularly removing dust build-up from screens, ventilation shafts or windbreak walls will improve operational efficiency and can reduce odours by improving bird health and maintaining drier litter. Minimising dust levels will also reduce odour transmission (McPherson 2000, McGahan et al. 2002).

3. Poultry litter moisture content

Excessively wet litter is the main source of odour from meat chicken sheds. Jiang & Sands (2000) reported that reducing the moisture content within sheds and maintaining litter pH above 7.5 could effectively reduce odour emission from meat chicken sheds by inhibiting anaerobic bacterial activity.

The optimal shed litter moisture content to minimise odour generation and provide a healthy environment for workers and birds is between 15% and 30% (wet basis) (NSW Meat Chicken Guidelines, 2002).

Dietary upset caused by feed formulation, medication or poor bird health can produce extremely wet manure, high litter moisture content and odours. Regular monitoring and close communication between growers and chicken and feed suppliers (usually processors) can help reduce such problems.

On hot days, temperatures in conventional sheds are reduced by using fans and foggers to create a cooling mist. But extended or frequent fogger use unfortunately results in wet birds and litter, especially if foggers are poorly maintained causing uneven flow and leaks. Condensation due to poor insulation or ventilation also contributes to wet litter.

In controlled-environment sheds foggers may be used as a backup during extreme temperatures but the primary cooling devices are wind chill and external evaporative cooling pads. The increased airflow and improved feed conversion in tunnel-vented sheds further helps to maintain shed litter within the optimal moisture content range.

In all shed types poorly maintained drinking lines can create localised wet spots. Even quite small wet areas can significantly increase odour emissions and should be addressed by promptly repairing any faulty watering systems and either removing and replacing the wet litter or topping up with clean, dry bedding material.

Actions and shed designs which help ensure optimal litter moisture content include:

- effective cooling systems that provide optimum growing conditions and minimise the need to use internal foggers;
- monitoring and adjusting cooling systems and bird drinkers to avoid spillage, leaks and uneven distribution;
- appropriate stocking densities and attention to bird health;
- regularly breaking up and removing caked litter beneath drinking lines;
- adequate roof overhang and sidewall height to stop rainwater from entering the shed;
- insulating shed roofs to avoid internal condensation and promptly repairing any leaks in walls and roofs.

4. Dietary manipulation

A study of the effects of reducing crude protein levels in feed and simultaneously enhancing dietary amino acid levels (reported in McGahan et al. 2002) found that, after three batches:

- the litter had a lower moisture content and pH;
- the relative concentrations of equilibrium ammonia gas and total ammoniacal nitrogen in the litter was lower (approximately 90% and 50% lower respectively); and
- production performance was not compromised (between 1.8 and 2 kg feed per kg liveweight gain).

However, studies of the correlation between ammonia reduction and odour emissions across a range of industries have produced conflicting results. While some studies have found that reducing ammonia can reduce odour levels, recent research on odour emission from meat chicken sheds (Jiang & Sands 2000) found no correlation between ammonia and odour concentration.

The variable outcomes may be due to a masking effect where the removal of one odour (e.g. ammonia) may allow other previously neutralised or less dominant odour compounds in the emissions to be detected. Empirical evidence also indicates that the peak period of ammonia generation may not correlate with the period of peak odour emissions and complaints.

Further research is required to assess the effectiveness of dietary manipulation as an odour control strategy.

5. Litter and dead bird management

The removal of litter from poultry sheds will inevitably generate dust and odours. But the risk of odour impact is increased when mild breezes are blowing from the sheds towards nearby residences. In the early morning or towards night, cold air drainage can also carry odours considerable distances downslope. Odour movement is also affected by temperature inversions and can reach relatively distant residences. Wherever possible avoid handling litter in adverse climatic conditions.

If spent litter is applied on-farm, odour impacts can be minimised by careful selection of storage areas, assessing predicted wind direction and strength, avoiding adverse weather conditions and weekend work as well as applying litter at the correct rate. Incorporating the spent litter as soon as possible can also help. Recommendations for storing and using poultry litter are provided in the Agnote *Best practice guidelines for using poultry litter on pastures*.

Inappropriate handling of dead birds (e.g. substandard incinerators or composting practices) can also cause odour problems and complaints from neighbours.

Dead birds should be collected from sheds each day and refrigerated or frozen if not immediately disposed of.

Recommended disposal options (subject to Council approval) include:

- composting in appropriately designed and managed litter heaps or in approved and appropriately maintained composters of suitable capacity;
- off-site disposal in an authorised landfill or recycling facility or on-site burial in a covered pit (located to avoid groundwater or surface water contamination); and
- incinerators of suitable capacity that have been approved and properly maintained.

OTHER OPTIONS FOR REDUCING ODOUR IMPACTS

A further way of minimising odour conflict is to modify the concentration or type of odours released so they are not detectable at nearby residences or are considered to be inoffensive.

Various means of encouraging biological or chemical interactions or increasing dispersion have the potential to mask or dilute the concentration of odorous gases released. However, a very large reduction in odour concentration (up to 90%) seems to be necessary for effective abatement of odour problems (McGahan et al. 2002).

The options currently available that are able to significantly reduce odour tend to be poorly suited for commercial scale meat chicken sheds. However, a number of options warrant further research, as noted in the following discussion of existing and emerging technologies and in Table 2.

6. Odour neutralising or inhibiting agents

Various commercially available products are used as additives to feed, drinking water or litter to help inhibit the anaerobic degradation of shed litter or as agents that react with odour compounds to neutralise their offensiveness. Most are relatively easy to adopt and involve low capital costs but there is limited scientific assessment on their effectiveness in controlling odour.

Many neutralising agents use chemical interactions to remove or reduce ammonia released inside the shed but this does not necessarily reduce odour emission rates. This has been further supported in a 1997 study on two commercially available products, clinoptilolite zeolite and De-odorase*, reported by McGahan et al. (2002). Other compounds such as zeolite may be effective in removing odours

Table 2. Options for odour minimisation, treatment or isolation

Method	Odour removal	Advantages	Disdvantages	Cost
Strategic planning	Separates incompatible development	Preventative	May not suit existing set-up Buffer purchase expensive	–
Good practice and design	Minimises odour by optimising litter moisture content and bird health	Production benefits and cost savings Effective at source	Requires consistent application	Minimal
Dietary manipulation	Minimises odour by optimising litter moisture content and bird health	Effective at source Production benefits	More research required Growers have limited influence	Unknown
Used litter and dead bird management	Reduces cumulative odours	Environmental benefits Effective at source	Limited period of impact Localised Upgrading cost if required	Variable
Odour neutralising or inhibiting	Low	Works at source Easy to apply Low capital cost	Uncertain link between odour and ammonia More research required	Low
Tree breaks	May redirect wind flows or aid dispersion	Visual barrier May remove dust	Relies on dispersion Takes time to establish	Low
Windbreak wall	Moderate Aids dispersion	Simple May remove dust	Relies on dispersion More research required	Low
Short stacks	Moderate Aids dispersion	Simple Low maintenance	Relies on dispersion	Moderate
Air scrubbers; washing wall	Variable Uses water flow to remove ammonia and other particles	Effective for other industries Removes dust	High water use and effluent Ventilation rate critical High capital cost High maintenance Simpler ones less effective	Moderate to high
Ozone treatment	Potentially high More research required	Sterilises Removes dust	High capital cost Humid weather More research required	High
Biofilters	Effective for other industries	Effective for other industries	Complex High capital cost High maintenance High nitrogen effluent	High

Adapted from: McPherson (2000) and McGahan et al. (2002)

but because they also attract moisture they are impractical in poultry sheds.

Jiang & Sands (2000) suggested that adding lime to fresh litter may inhibit odour generation by restricting anaerobic breakdown. Further research is required to quantify the effects on odour emission rates, possible impacts on bird health and the cost-effectiveness of this option.

7. Tree planting (vegetative screens or windbreaks)

Appropriately designed and located windbreaks can help redirect air movement around sheds, and reduce dust movement. Mature windbreaks may also help mask and disperse odours over short distances (EPA 2000), but their main benefit is to reduce the visibility of sheds.

Odour complaints are often a result of heightened sensitivities and the visual impact of poultry amenities. By reducing the visibility of sheds it is possible to influence perceptions of how appropriate it is to have the enterprise within a locality. Screening sheds also encourage the identification of other possible odour sources.

The effectiveness of vegetative windbreaks depends on good design, site preparation, species selection (preferably local to the site) and effective maintenance including regular weed control and watering during the first two years. Windbreak

design also needs to avoid adversely reducing airflows within the sheds or creating unwanted shading.

8. Windbreak walls

Constructing a fixed 3 m high barrier a few metres from exhaust fans can help reduce the concentration of odours at nearby dwellings or public areas by directing expelled air upwards, which increases turbulence and the dispersion of odours. Windbreak walls also encourage odour-carrying dust particles to drop out of the airflow.

Preliminary studies by Bottcher et al. (2000) identified that tarpaulin windbreak walls could reduce odour concentration in sensitive locations by 30% to 90%. However, the dilution effect is limited to relatively short distances and is significantly reduced during calm conditions. In strong wind conditions the dilution effect is also reduced due to the existing high levels of airflow and turbulence.

Windbreak walls are relatively easy to install on new or existing sheds at relatively low cost. Possible materials include concrete panels, sheet iron, hay bales, brushwood or tarpaulins stretched over timber or metal frames – but the visibility of the structure must be considered.

9. Short stacks

Short stacks attached to exhaust fans direct odorous air upwards, increasing the chance for the plume to disperse before reaching the ground. A study by Pollock & Friebel (2000) on the effectiveness of 5 m tall stacks in diffusing night-time odours found that the distance from the poultry farm at which odour levels of 5 Odour Units were detected (99.9 percentile for an averaging period of 3 mins) was reduced from 300 to 170 m (McGahan et al. 2002).

The additional turbulence from short stacks and corresponding reduction in odour concentration at ground level is most effective over relatively short distances (200–500 m) from the sheds. Strong winds or unstable conditions will minimise this effect.

Recent research (reported in Mc Gahan et al. 2002) identified short stacks as being more effective than taller stacks because of the additional turbulence that air flows around the sheds create in the stack discharge zone. (Such effects would be less pronounced during calm conditions.)

10. Air scrubbers and washing walls

Air scrubbers cause exhaust gases to absorb into a liquid stream and are an effective means of removing airborne contaminants and odours from industrial exhausts. The removal of odorous air from fish processing and rendering plants by high pressure Venturi scrubbers is known to be greater than 99%. However, such technology is unlikely to be viable for meat chicken sheds due to the complexity and cost of such systems (McGahan et al. 2002).

A simpler pressure scrubber system tested by McPherson (2000) generally removed around 10% of dust particles and some ammonia but was ineffective at reducing odour from meat chicken sheds. The large airflow at relatively low odour concentration from poultry sheds would also require substantial infrastructure and water flows which are not economically or environmentally justified.

An alternative is to create a washing wall by placing a vertical pad of continually wetted material 1.5 m upstream of the exhaust fans (McPherson 2000). While capable of removing significant dust and ammonia at medium ventilation rates, washing walls are not that effective in extremes of ventilation conditions that are common in poultry meat sheds.

An even simpler method bubbles odorous air through a tank of water (McGahan et al. 2002). While a significant proportion of ammonia may be removed, the water needs to be continually bled off and replaced to remain effective which creates a large volume of effluent and increases the cost.

Fixed-bed packed scrubbers minimise the use of water by directing odorous airflow through towers packed with plastic or ceramic material over which a thin film of water flows. The volume of air that can be treated is limited by the height of the tower and water pressure. To remain effective both the water and materials also need regular replacement. Hence this option is not well suited to poultry sheds (McGahan et al. 2002).

11. Oxidisation (ozone and oxygen treatments)

Ozone is used in various industries to kill airborne bacteria, deodorise odours and remove particles. Its strong oxidising properties are claimed to neutralise a broad range of odorous compounds, including those known to occur in poultry sheds. However, quantifiable information on the odour-removing effectiveness of ozone is limited and it may not work in humid conditions.

McGahan et al. (2002) reports that trials using low levels of ozone (0.1 ppm) to deodorise and reduce airborne bacteria in sheds stocked with birds are promising. Further research is required on the cost-effectiveness of ozone in reducing odour and dust, any impacts on production or bird health and its safety. Ozone systems also involve considerable capital and operating costs that are not currently justified for the meat chicken industry.

Active oxygen is a recent technology which passes oxygen over charged electrical sources to increase the capacity to oxidise odorous compounds. This system relies on mixing energised oxygen with odorous compounds in a stack or exhaust chimney but the

set-up and running costs are too expensive for use in meat chicken sheds.

12. Biofilters

In biofiltration a steady flow of exhaust air is passed through a bed of moist organic material inhabited by specialised bacteria that break down and oxidise odorous compounds.

Constant airflow, temperature and moisture levels are required to maintain the micro-organisms. Excessive moisture increases airflow resistance and may encourage anaerobic conditions. Insufficient moisture deactivates the microbes and allows channels to form in the substrate. Ongoing control of rodents and excessive vegetative growth is also necessary to ensure effective operation.

Correctly designed and maintained biofilters have proven effective for pig and calf sheds overseas but are less suitable for commercial chicken meat sheds due to:

- high ventilation rates involved, and the capital cost of suitable systems
- high maintenance requirements to ensure the substrate and organisms are effective
- effluent produced from maintaining and cleaning the filter material.

A simpler variation is the biomass filter, which removes dust and odours by forcing exhaust air through a vertical wall of organic material (e.g. chopped corn stalks) held in place by a timber and wire frame. Such options are still being trialled but the cost may be relatively similar to biofilters.

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DISCLAIMER

The information contained in this publication is based on knowledge and understanding at the time of writing (February 2004). However, because of advances in knowledge, users are reminded of the need to ensure that information upon which they rely is up to date and to check currency of the information with the appropriate officer of New South Wales Department of Agriculture or the user's independent adviser.

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