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Review

Odour emissions from poultry litter – A review litter properties, odour formation and odorant emissions from porous materials

Mark W. Dunlop [a, b, c, *], Patrick J. Blackall [c, d], Richard M. Stuetz [b]

[a] Department of Agriculture and Fisheries, Queensland Government, Toowoomba, Qld 4350, Australia
[b] University of New South Wales, School of Civil and Environmental Engineering, Sydney, NSW 2052, Australia
[c] Poultry CRC, PO Box U242, University of New England, Armidale, NSW 2351, Australia
[d] The University of Queensland, Queensland Alliance for Agriculture and Food Innovation, St Lucia, Brisbane 4067, Australia

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ABSTRACT

Odour emissions from meat chicken sheds can at times cause odour impacts on surrounding communities. Litter is seen as the primary source of this odour. Formation and emission of odour from meat chicken litter during the grow-out period are influenced by various factors such as litter conditions, the environment, microbial activity, properties of the odorous gases and management practices. Odour emissions vary spatially and temporally. This variability has made it challenging to understand how specific litter conditions contribute to odour emissions from the litter and production sheds. Existing knowledge on odorants, odour formation mechanisms and emission processes that contribute to odour emissions from litter are reviewed. Litter moisture content and water thermodynamics (i.e. *water activity*, A_w) are also examined as factors that contribute to microbial odour formation, physical litter conditions and the exchange of individual odorant gases at the air-water interface. Substantial opportunities exist for future research on litter conditions and litter formation mechanisms and how these contribute to odour emissions. Closing this knowledge gap will improve management strategies that intercept and interfere with odour formation and emission processes leading to an overall reduction in the potential to cause community impacts.

Contents

* Corresponding author. Department of Agriculture and Fisheries, 203 Tor Street, Toowoomba 4350, Qld, Australia.
E-mail address: mark.dunlop@daf.qld.gov.au (M.W. Dunlop).

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1. Introduction

Emission of odour from litter in meat chicken sheds (broiler houses) can lead to odour nuisance within the surrounding community and potentially result in complaints (Carey, 2004; Guo et al., 2003; Hayes et al., 2014; Radon et al., 2004). Odour is a normal part of meat chicken production due to anaerobic and aerobic microbial activity in the litter and also due to its release from the animals (Pillai et al., 2012). Litter is considered to be the primary source of odour from meat chicken sheds because the majority of odorous compounds are released during the decomposition of organic matter (Hobbs et al., 2004; Mackie et al., 1998). Odour from meat chicken sheds is a complex mixture of odorous compounds typically composed of volatile organic compounds (VOCs) and non-VOCs (e.g. ammonia, hydrogen sulfide, reduced sulfur compounds) (Cai et al., 2007).

Conditions within the litter influence the formation and emission of odorants resulting in changes to the concentration and character of the odour exhausted from meat chicken sheds (Spoelstra, 1980; Wadud et al., 2012). It is suggested that it may be possible to reduce the odour nuisance potential of meat chicken farms by altering this odour mixture in a way that makes the odour less detectable or offensive to the neighbouring community.

Scientific studies and reviews have focussed on general topics about odour from agricultural, industrial and municipal sources (Table 1). This literature provides an understanding of the complexities of odour and odour impacts, but the current specific need is to identify literature that relates to quantifying the properties of meat chicken litter and how these properties influence odour emissions. In this review, the term ‘litter’ will specifically refer to meat chicken litter.

Relatively little information has been reported about the formation of poultry odour compared to other livestock industries, especially pig production (Cai et al., 2007; Trabue et al., 2010). Litter is a very different odour source than other intensive animal bedding/wastes including those from laying hens, pigs and cattle. As such, literature published for these animals was reviewed but only considered to be relevant if specific aspects were likely to be fundamentally similar to meat chicken litter. Unfortunately, some published research does not specifically identify which animal species were involved, instead referring to ‘animal wastes’ or ‘poultry’, which does not differentiate between meat chickens or laying hens. There are many differences between meat chickens and laying hens in terms of breed, nutritional requirements, feed formulations, length of production cycle and housing design that are likely to support different odour forming mechanisms. Additionally, some published studies refers to odour emissions from poultry manure or poultry litter/manure composting (Petric et al., 2009; Sweeten et al., 1991; Turan et al., 2007). Accumulation of manure/litter within meat chicken sheds may be considered a form of stockpiling/composting and there will be some similarity to in-shed litter, but conditions in terms of the environment, microbial activity, surface to volume ratio, fresh manure addition and mechanical mixing due to chicken activity are likely to be different.

Litter is a porous material and odorants will be released from the surface (Mackie et al., 1998) but will also diffuse through the pores (Schwarzenbach et al., 2003; Thibodeaux and Scott, 1985; Zhang et al., 2002). Release of odorants from litter is therefore complex and requires consideration of gas exchange mechanisms and litter physical properties.

The aim of this review is to describe how conditions within litter influence the formation and diffusion of odorants from litter as well as considering how shed and litter management strategies influence litter conditions. Odorants previously identified at meat chicken farms will be summarised. The effect of litter porosity on the exchange of odorants between the litter and ventilation air will

Table 1
Overview of selected studies on odour from agricultural, industrial and municipal sources.

Odour research topics	References
Odour metrics (concentration, intensity, hedonic tone, character)	Fournel et al. (2012); Lebrero et al. (2011); Nimmermark (2011)
Odour measurement (olfactometry)	Hamon et al. (2012); Jacobson et al. (2008); Lebrero et al. (2011); van Harreveld et al. (1999)
Instrumental odorant measurement such as gas chromatography–mass-spectrometry/olfactometry (GC-MS/O), selected ion flow tube–mass spectrometry (SIFT-MS) or proton transfer reaction–mass spectrometry (PTR–MS)	Cai et al. (2006); Hamon et al. (2012); Hansen et al. (2012); Heynderickx et al. (2013); Lebrero et al. (2011); Muñoz et al. (2010); Ni et al. (2012); Van Huffel et al. (2012); Zhang et al. (2010)
Odour sampling methodologies (e.g flux chamber vs wind tunnel methods for area sources, and sample storage prior to analysis)	Brockreis and Steinberg (2005); Capelli et al. (2012); Capelli et al. (2013a); Capelli et al. (2013b); Guillot (2012); Hudson and Ayoko (2009); Hudson et al. (2009); Jiang and Kaye (1996); Lebrero et al. (2011); Parker et al. (2013a); Parker et al. (2010a); Parker et al. (2010b)
Odorant chemistry and composition, formation and emission (flux)	Cai et al. (2006); Hamon et al. (2012); Hudson and Ayoko (2008); Hudson et al. (2009); Mackie et al. (1998); Ni et al. (2012); O'Neill and Phillips (1992); Trabue et al. (2010); Turan et al. (2007)
Odour impacts (frequency, intensity, offensiveness, duration, location/receptor characteristics)	Lebrero et al. (2011); Mackie et al. (1998); O'Neill and Phillips (1992)
Odour management or treatment	Hamon et al. (2012); Lebrero et al. (2011); Massé et al. (2013); Ullman et al. (2004);