Available online at www.sciencedirect.com
SCIENCE DIRECT®
Bioresource Technology 97 (2006) 2002–2014
BIORESOURCE TECHNOLOGY

Assessment of permeable covers for odour reduction in piggery effluent ponds. 1. Laboratory-scale trials

N. Hudson *, D. Duperouzel, S. Melvin

Department of Primary Industries and Fisheries Queensland, P.O. Box 102, Toowoomba, Qld 4350, Australia

Received 22 June 2004; received in revised form 14 June 2005; accepted 4 November 2005
Available online 2 February 2006

Abstract

A variety of materials were trialed as supported permeable covers using a series of laboratory-scale anaerobic digesters. Efficacy of cover performance was assessed in terms of impact on odour and greenhouse gas emission rate, and the characteristics of anaerobic liquor. Data were collected over a 12-month period.

Initially the covers reduced the rate of odour emission 40–100 times relative to uncovered digesters. After about three months, this decreased to about a threefold reduction in odour emission rate, which was maintained over the remainder of the trial. The covers did not alter methane emission rates. Carbon dioxide emission rates varied according to cover type. Performance of the covers was attributed to the physical characteristics of the cover materials and changes in liquor composition. The reductions in odour emission indicate that these covers offer a cost-effective method for odour control.

Keywords: Anaerobic; Odour; Emission; Management; Supported; Straw; Permeable; Cover; Laboratory-scale

1. Introduction

The Australian pig industry has undergone considerable change over the last 40 years. The number of producers has declined from nearly 50,000 to about 3000, while the average number of sows per herd has increased from 4.3 to over 100 over this period (Meo and Cleary, 2000). While this intensification has made economies of scale possible, it has also increased the potential for adverse environmental impacts. This has been particularly true with regard to odour emissions. The problem has been exacerbated by the encroachment of urban and peri-urban settlement into areas that were previously devoted to primary production (Henry, 2001). In addition, the expectations of rural residents are shifting, resulting in less tolerance of loss of amenity value (Halasz, 2001). In a recent review regarding the relationship between odour exposure and health, Schiffman et al. (2000) confirmed that odours do impact human health. They also identified three basic mechanisms whereby odour impacted on health:

- symptoms induced by exposure to high concentrations of odorants (irritation rather than odour), with odour serving as a marker;
- health effects occurring in response to exposure to odorants at concentrations that were not irritating;
- the odorant as part of a mixture containing a co-pollutant that is responsible for the health symptom (odour acting as an exposure marker).

The authors concluded that identification of a link between odour exposure and health effects, intensification of livestock industries and rural encroachment were all increasing pressure on primary producers to reduce odour emission generally. They also drew attention to the fact

* Corresponding author. Tel.: +61 7 4688 1519; fax: +61 7 4688 1192.
E-mail address: neale.hudson@dpi.qld.gov.au (N. Hudson).

0960-8524/$ - see front matter © 2005 Published by Elsevier Ltd.
doi:10.1016/j.biortech.2005.11.002

that health effects could be reduced through implementation of well-managed odour remediation techniques (Schiffman et al., 2000).

A range of odour management techniques are available to producers including: dietary manipulation (Hobbs et al., 1996, 1997); biofilters (Martin et al., 1996; Sun et al., 2000); covers for storage and treatment structures (Meyer and Converse, 1982; Sommer et al., 1993; Hodgson and Paspaliaris, 1996; Zhang and Gaakeer, 1998; Xue et al., 1999; Hornig et al., 1999; Picot et al., 2001); improved digester techniques (aerobic and anaerobic), with or without improved solids separation devices (Sneath et al., 1992; Tao et al., 1998; Beline et al., 1999; Bicudo et al., 1999; Paing et al., 2001); composting of biosolids (Vuorinen and Saharinen, 1997; Tiquia et al., 1998; Hong et al., 1998; Jeong and Kim, 2001), and advanced treatment techniques, such as activated sludge processes, upflow sludge bed digesters, sequencing batch reactors, with or without off-gas treatment facilities (Subramaniam et al., 1994; Sanchez et al., 1995; Powers et al., 1997; Cheng and Liu, 1998; Dugba and Zhang, 1999).

While there is a requirement for methods to manage or minimise the impact of gaseous emissions on local communities, including loss of amenity value and possible health effects, certain criteria need to be met when identifying tools for managing odour impacts. These criteria include:

- techniques to be of low capital cost;
- equipment to be easily installed and require minimal management;
- maintenance to be limited and affordable; and
- odour control should be efficient and consistent over the life of the equipment.

In addition, it is necessary for remediation methods to be compatible with existing waste management practices and equipment. Considerable expense has been incurred installing and developing the waste management systems currently in use at various enterprises. Complete replacement or significant redundancy of existing infrastructure would be unacceptable to the industry.

While straw-based housing has become popular in some areas, currently most Australian piggeries comprise a naturally ventilated, slatted floor housing system, and an effluent removal system, generally comprising underfloor flushing channels. Manure treatment or stabilisation is predominantly achieved using one or more open storage or stabilisation ponds. Typically, supernatant liquor is recovered from one of the ponds and periodically used to flush the housing system, conveying urine, faecal matter and spilt feed and water to an anaerobic pond. Pre-treatment occurs at some piggeries, and may include removal of separated solids. Recovered solids would be handled in a system operating in parallel to the liquid treatment system. Fresh water is periodically added to the effluent stream to reduce the increase in salinity caused by evaporation from the pond and input of salts from animal feed and wastes. Odours are generated from each component of the intensive livestock operation.

While a variety of potential options exist to reduce odour emissions, it is important to identify the components of a piggery from which most of the odour is emitted to ensure most effective remediation. In Australia, odour emissions from piggeries were apportioned between housing structures (20%) and effluent ponds (80%) (Schulz and Lim, 1993; Dalton et al., 1997). The estimates were confirmed more recently, while it was also shown that the proportion of the total emission from these sources was dependent on the scale of the operation (Smith et al., 1999).

While a number of options are potentially available for odour control, in most cases considerable expense would be entailed in deploying these techniques on farm. The challenge is therefore to identify odour control techniques that can be added to existing systems. Pond covers are attractive because they can be added to existing waste treatment systems.

It has been long known that covering an odour source decreases or eliminates odour emission (Baum, 1975). Early attempts to cover large anaerobic piggery ponds appear to have emerged from the observation that the floating mat or scum that formed on beef or dairy waste ponds reduced odour emission. Meyer and Converse (1982) reviewed the use of a range of cover materials to reduce odour emissions. With the exception of a cover comprising small floating plastic balls, other cover types appear to have incorporated a biofilter to treat off-gases as well as a cover. Among the artificial scum materials trialed were rice hulls, sawdust, ground corncobs, chopped cornstalks, grass, wood shavings, dairy manure, waste oil, mineral oil and vegetable oil. Only materials coated with waste oil floated for the entire 134-day test period. All treatment types were judged to be more effective than the uncovered control, prompting the authors to claim, "*artificial scum treatment could be a fast, low-cost remedy to an odour problem*" (Meyer and Converse, 1982).

Mannebeck (1986) researched the impact placing a cover on manure storage tanks might have on odour emissions, with a focus on establishing artificial floating crusts on the storage tanks. Chopped straw, plastic foam pellets and combinations of these materials were used. Air-tight covers constructed from tarpaulins were trialed as unsupported covers or were suspended above the tank contents, creating an air space. Biofilters were used to treat the off-gas from the tanks with impermeable covers. A 40–60% odour reduction was reported for artificial floating crusts (straw and/or foam pellets), whereas 60–90% reduction was claimed for natural floating crusts. Floating tarpaulins and impermeable roof-type covers achieved 75–100% reduction in odour emission.

The Prairie Agricultural Machinery Institute (PAMI) undertook a series of five projects that aimed to develop effective odour control coverings on pig effluent ponds (PAMI, 1993). Their work focussed on the application of a layer of straw to the surface of a pond, either as a