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Methane, nitrous oxide and ammonia emissions from an Australian piggery with short and long hydraulic retention-time effluent storage

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Short HRT Emission Measurement System Description

The gases in the head space of the short HRT system were analysed using a modified OP-FTIR spectrometer coupled to a 1.5 m long PVC tube (100 mm diameter) with a corner cube mirror (retro reflector) mounted at the end to return the outgoing beam along the same optical axis to the detector. The PVC tube formed the measurement cell and was supported on a 2 m length of optical rail which defined an optical axis. The cell and instrument enclosure were coupled together with rubber sheet to form a seal. The cell was vented at the spectrometer, with the sample inlet located close to the retro-reflector. The system was calibrated in the laboratory against known standards, and integrity of the system confirmed following deployment.

The air in the head space was sampled through the 90 mm sampling outlet which reduced to 50 mm flexible irrigation pipe. The method of sampling the head space differed slightly between the two trials.

Winter Trial: A second airline (50 mm flexible irrigation pipe), with the inlet mounted close to the tank cowling, sampled background air. The two sample lines were attached to a manifold constructed from 50 mm PVC pipe fittings and 2 x 2" diaphragm assisted solenoid valves (Process Systems Air and Fluid Control, Econo Series ES55). A single pipe connected the manifold to the inlet of the measurement cell. An 80 mm computer fan, mounted in a tapered 50-100 mm PVC coupling, moved air through the system, and an inline mass flow meter (Sierra Instruments, Montery, CA – Top Trak 820 Series 0-100 L/min) measured air flow. Sampling alternated between the tank and background sample lines in a 15-min measurement cycle, with 5 x 3-mins averaged spectra collected each cycle. The residence time for the system, the time taken for gas to be cleared between the manifold and measurement cell on switching between intake lines, was 3-6 minutes and to remove any contamination when alternating between lines, the initial two measurements of each cycle were discarded from the analysis.

Summer Trial: The manifold and flow meter were removed as they caused a substantial restriction to the air flow. The flow meter was replaced by an 85 mm diameter wind anemometer (Schiltknecht MiniAir6 Macro, 0-20 m/s) and a single sample line method was adopted. Air was moved through the system by a household exhaust fan (HMP 100 mm Slimline) housed in a tapered 50-100 mm PVC coupling placed in-line before an 80 mm diameter computer fan mounted in an identical PVC coupling. The tank head space was sampled continuously except when background air was sampled, typically every 3-4 days, by disconnecting the sample line and sampling the background air manually.

Pressure (Visalla PTB100 Barometer) and temperature (LM335), required in the retrieval of gas mixing-ratio from the infrared spectra, were monitored inside the cell. Spectra were analysed immediately after collection to provide mixing ratios of NH_3, N_2O, CO_2, CH_4, CO and water vapour (MALT, Griffith 1996). Operation of the system, including valve switching and auxiliary data collection (flow, temperature & pressure) was fully automated (G. Kettlewell, University of Wollongong).

Table S1. Model parameters with uncertainty

		Trial 1			Trial 2			Uncertainty data source
Input parameters	**Units**	**Value**	**Uncertainty**		**Value**	**Uncertainty**		
Feed waste	frac	0.070	±	0.019	0.070	±	0.019	Uncertainty range based on literature – Willis (1999)
N content of pigs	kg/kg	0.029	±	0.008	0.029	±	0.008	Unpublished data – Skerman et al. (2015)
Ash content of pigs	kg/kg	0.036	±	0.010	0.036	±	0.010	Unpublished data – Skerman et al. (2015)
N content of feed	kg/kg	0.026	±	0.002	0.028	±	0.002	S.D from feed sample replicates from four diets
Ash content of feed	kg/kg	0.059	±	0.005	0.061	±	0.005	S.D from range of feed sample replicates from four diets
TS content of feed	kg/kg	0.897	±	0.006	0.921	±	0.006	S.D from range of feed sample replicates from four diets
N content of effluent	mg/L	1996	±	835	1400	±	741	S.D from 32 and 30 replicate sample results for Trial 1 and 2 respectively
Ash content of effluent	mg/L	5600	±	2118	4817	±	1731	S.D from 29 and 24 replicate sample results for Trial 1 and 2 respectively
Shed ammonia-N emissions [A]	kg	n.d	n.d	n.d	38	±	45	S.D from 16 daily average results for Trial 2

[A] No data collected in trial 1.