THE UNIVERSITY OF MELBOURNE

FACULTY OF VETERINARY & AGRICULTURAL SCIENCES

Mitigation of nitrogen losses with Australian zeolites during the anaerobic digestion of swine manure

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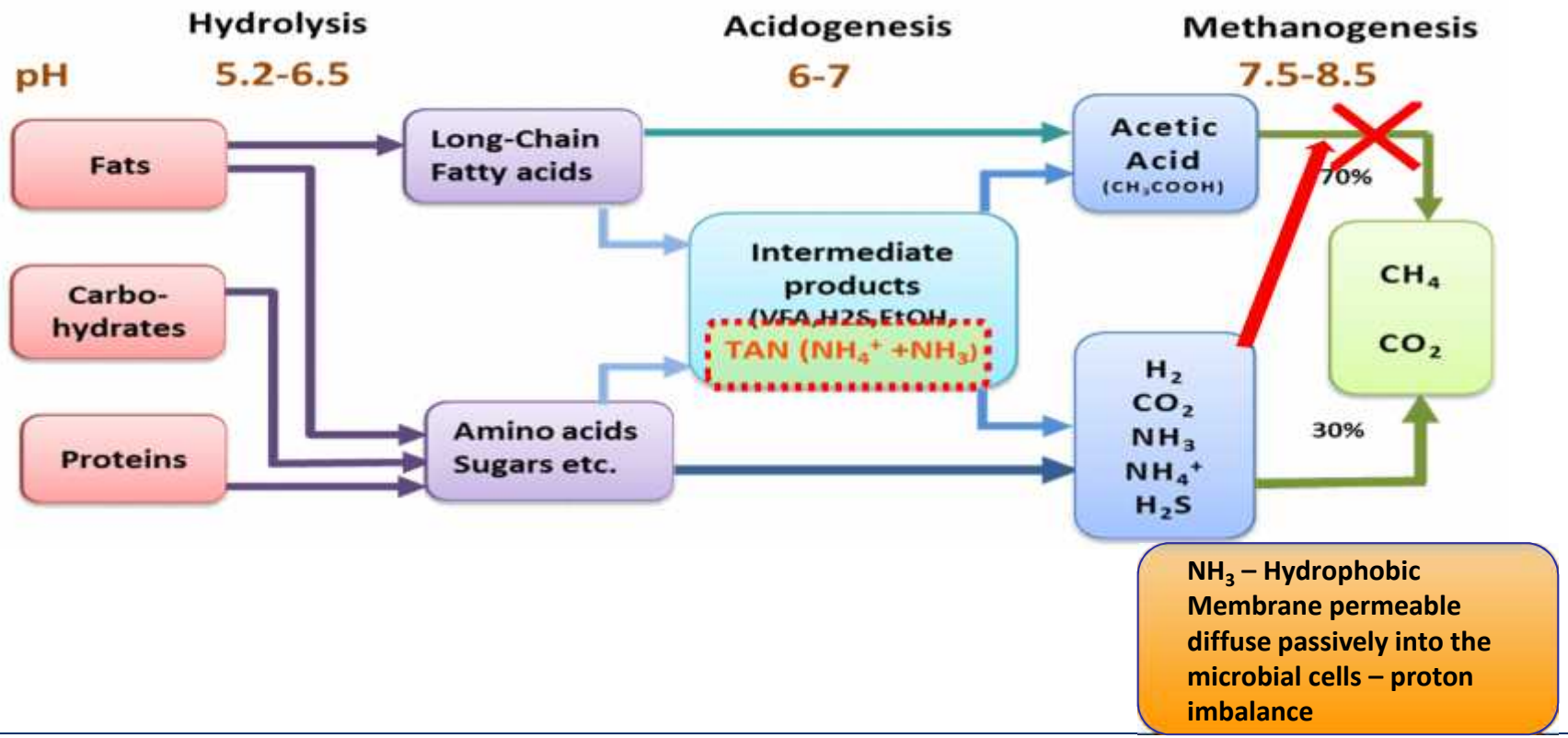
Swine industry in Australia

- Around 1500 pig farmers produce - 4.8 million pigs annually(1)
- Waste management
  - Huge quantity of wastes (150 – 250 L / sow / day)
  - 83% of operators use anaerobic lagoons
- Emissions
  - 66% of GHG emissions from the pig sector are from uncovered lagoons
- Solutions
  - Government's programs and policies to promote methane capture, Ex: anaerobic digesters
  - No applicable solution to nitrogenous gas emissions

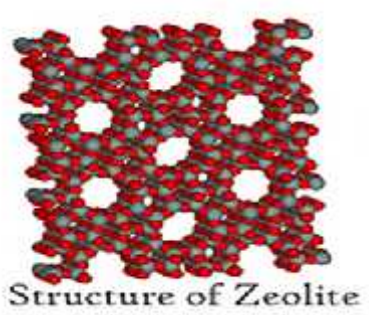
(ABS 2012), (APL 2014) (1) (NGGI 2005) (McGahan et al.2010), (Grant and Batten, 2013) (DAFF, 2008)(RIRDC,2013)

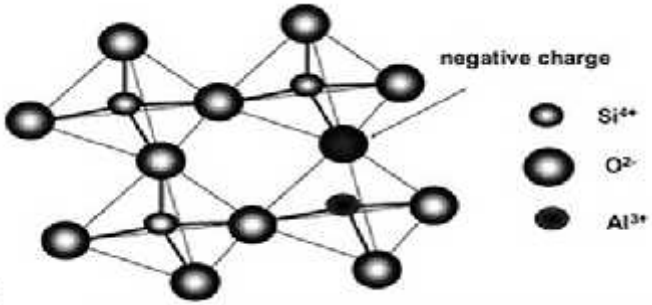
Bio-chemical process of AD



Zeolites

- Zeolites are hydrated alumino silicate minerals
- Highly micro porous crystalline structure

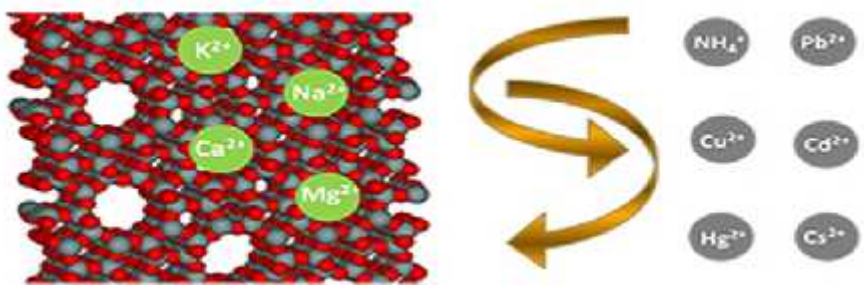

Structure of Zeolite



- Zeolites deposits exist in many parts of the world
- In Australia , Zeolite deposits are at Werris Creek, New South Wales, and Emerald, Queensland

Physical and chemical properties

- Act as “molecular sieves”
  - Ability to trap ions, water and/or other molecules
  - Lose and gain molecules reversibly
  - High adsorption property & high ion selectivity of NH_4^+
  - High ion-exchange property



- Each different zeolite has its own characteristics

Main research objectives

1. To determine the optimum zeolite dose that maximise ammonium recovery with enhanced methane production

2. To determine the impact of nitrogen removal on methane generation and anaerobic digestion process performance

Methodology

Experimental set-up

Experimental conditions

Digester Type	Zeolite addition rate g of zeolite/L of slurry
Swine Manure + Natural zeolite	0, 10, 40,70,100
Swine Manure + Sodium zeolite	0, 10, 40,70,100

Initial characteristics

Parameter	Swine manure	Inoculum
TS%	7 ±0.15	3 ±0.01
VS%	69 ±0.32	67 ±0.19
pH	6.73 ±0.05	7.39 ±0.01
sCOD (mg/L)	14725 ±214	1734 ±35
NH4-N (mg/L)	664 ±12	1298 ±9
N%	2.48 ±0.02	2.97 ±0.02
C%	33.54 ±0.13	31.76 ±0.16

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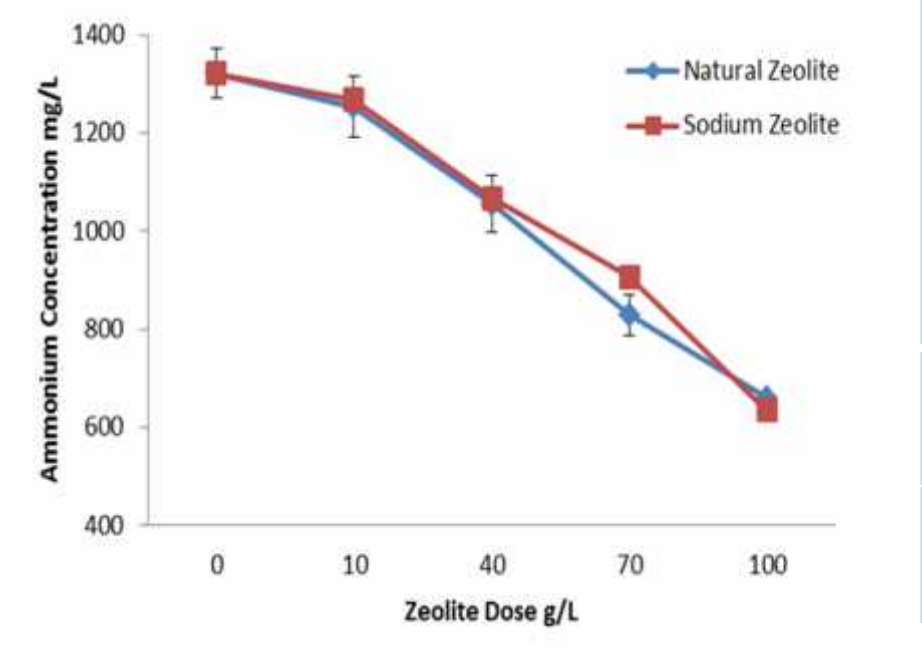
Arjun Pandey, 28-Nov-16

Final ammonium concentration



Type of Zeolite	Reduced NH_4^+ % compared to the no zeolite digesters			
	10g/L	40g/L	70g/L	100g/L
Natural Zeolite	5 ±2.7	20 ±4.4	37 ±3.19	50 ±2.18
Sodium Zeolite	4 ±0.75	19 ±1.38	31 ±1.11	52 ±0.83

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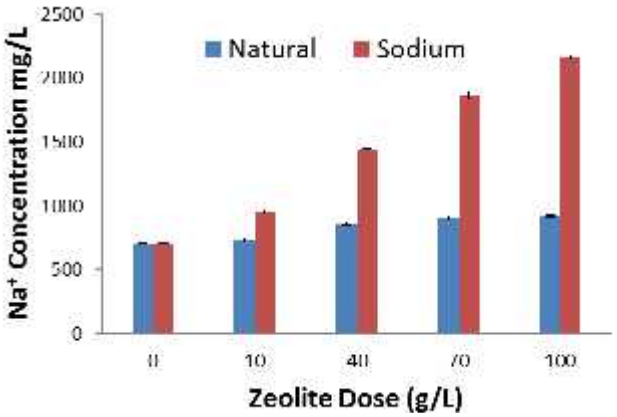
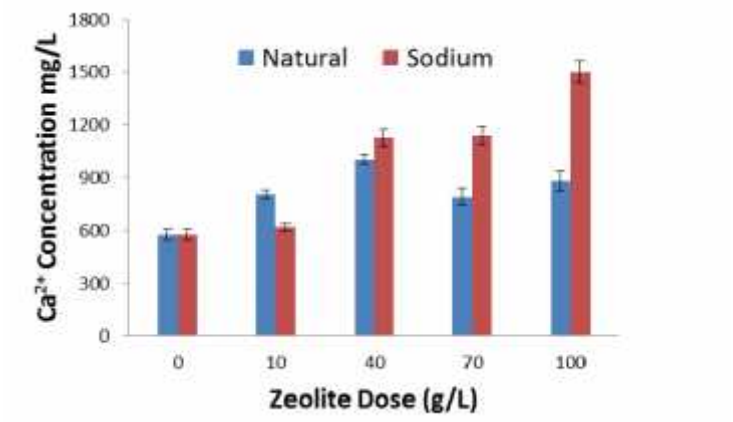
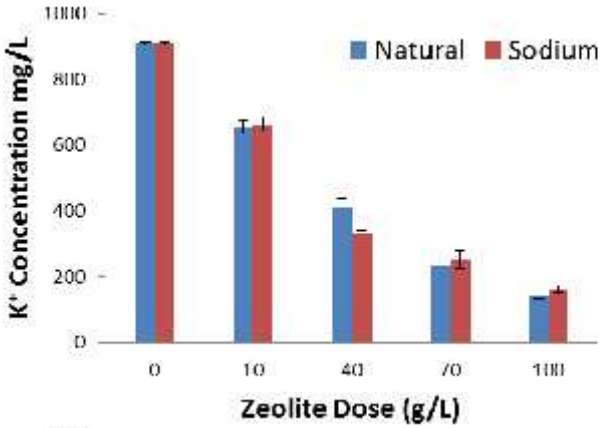
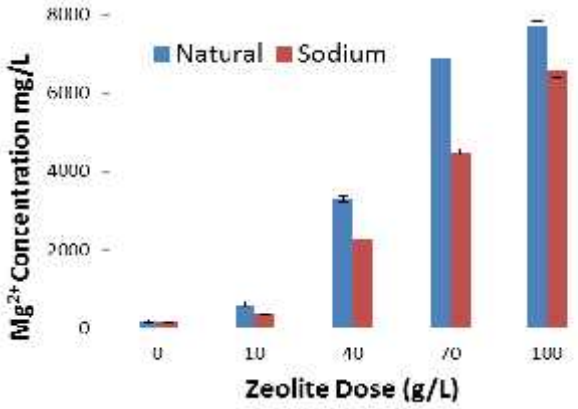
Final cation concentrations









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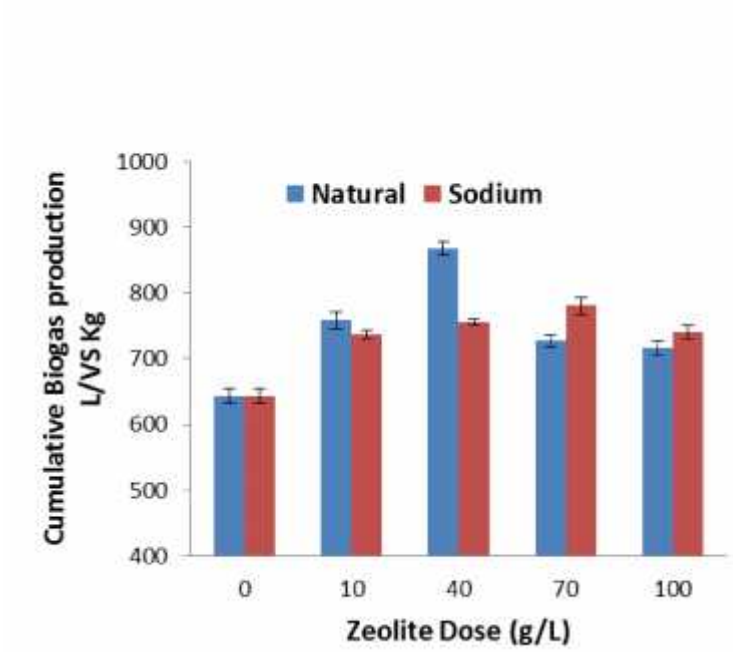
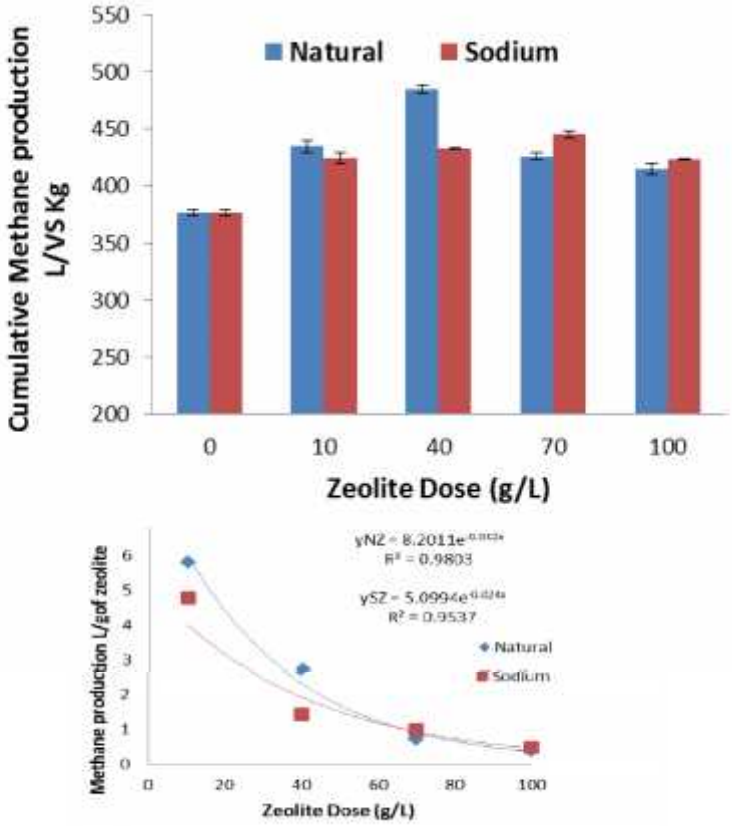
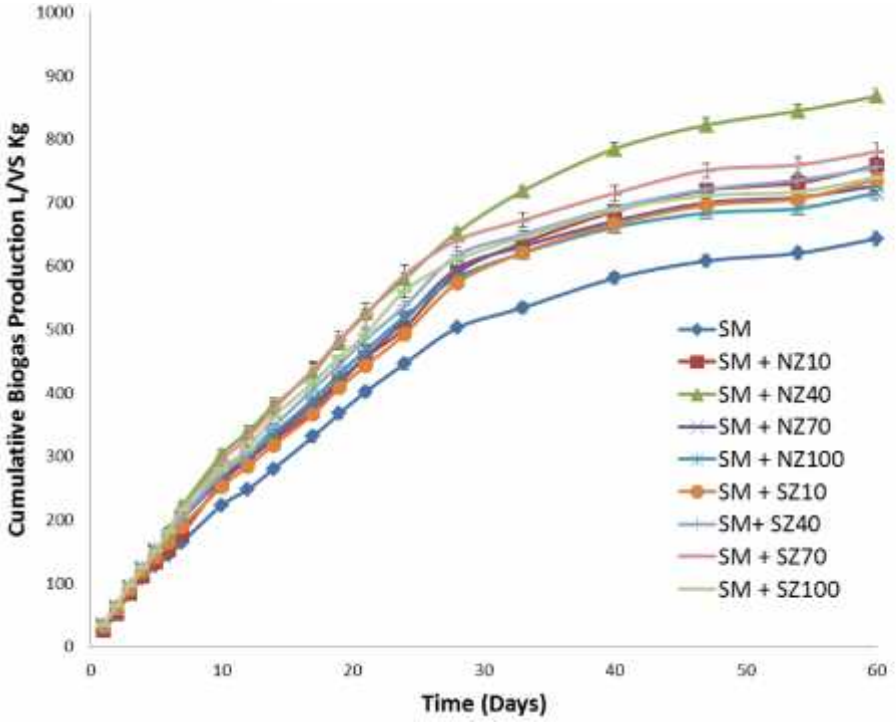
Biogas and methane production

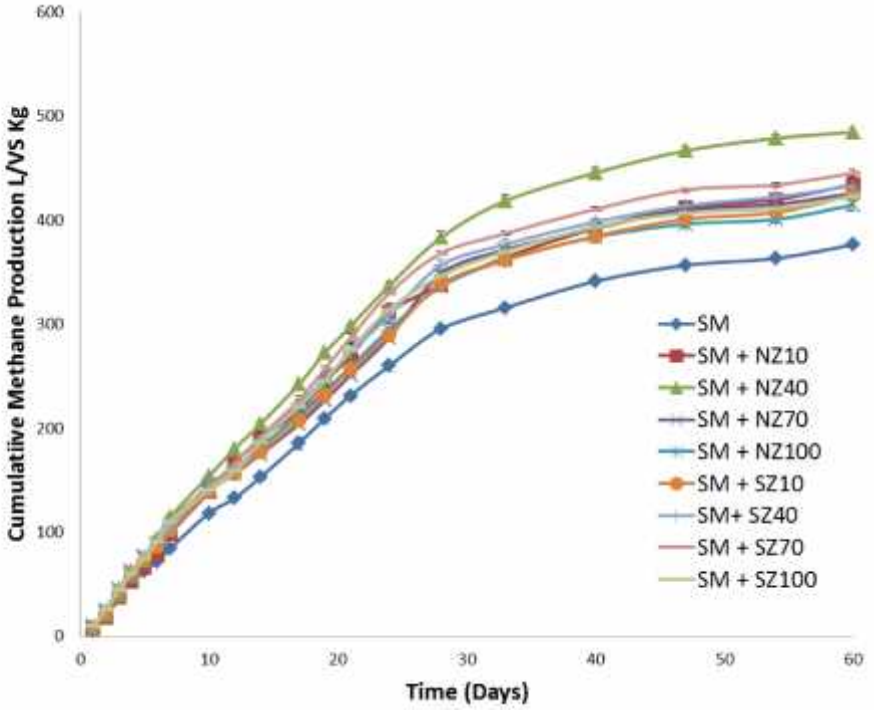




Biogas and methane production



Cumulative biogas production



Cumulative methane production

SM – Swine manure, NZ – Natural zeolite, SZ – Sodium zeolite

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Methane & ammonium changes

Type of Zeolite	10 g/L		40g/L		70 g/L		100 g/L	
	Enhanced % of CH_4	Reduced % of NH_4^+	Enhanced % of CH_4	Reduced % of NH_4^+	Enhanced % of CH_4	Reduced % of NH_4^+	Enhanced % of CH_4	Reduced % of NH_4^+
Natural Zeolite	15 ±1.4	5 ±4.7	29 ±1.05	20 ±4.4	13 ±0.85	37 ±3.19	10 ±1.33	50 ±2.18
Sodium Zeolite	13 ±1.21	4 ±0.75	15 ±0.18	19 ±1.38	18 ±0.89	31 ±1.11	12 ±0.16	52 ±0.83

Methane enhancement and ammonium reduction % compared to no zeolite digesters

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Conclusion

- Australian zeolites significantly enhance methane generation while adsorbing substantial quantity of ammonium from the medium during the anaerobic digestion process of swine manure
- The effects of natural and sodium zeolites are more or less similar during the anaerobic digestion of swine manure
- Although the higher doses of zeolite continue to reduce ammonium linearly, the increases in methane yield are marginal at doses above 40g/L

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More information:

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Ammonium removal from high-strength aqueous solutions by Australian zeolite

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Thank You

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