Australian Government
Department of Agriculture, Water and the Environment

AUSTRALIAN Pork

Strategic Evaluation of Opportunities and R&D Needs for Water Management in Piggeries

Final Report
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Background

Fresh water is required to produce Australian pork, with on-farm use of fresh water estimated at 55 - 65 L of water per sow-place per day for drinking (including spills) and cooling and an additional 20 - 29 L of fresh water per sow-place per day for wash down (APL, 2016; Murphy et al., 2016). The Australian pork industry has long been committed to environmentally sustainable production, including stewardship of natural resources such as water (APL, 2015). The pork industry has already adopted significant water savings initiatives such as well-designed drinkers, the use of treated effluent for shed flushing, or deep litter systems in suitable climates.

The cost of water supply for Australian pork production varies between State and district. The price of water can vary widely from relatively low cost for simply pumping of extracted ground or surface waters, up to relatively high cost for purchase of water from a potable mains water supply. Water scarcity could be an imminent threat to pork production in many regions of Australia. To provide perspective, a current typical cost of $2/kL (water entitlements in Murray-Darling (Department of Agriculture and Water Resources, 2016); typical domestic water prices are $4/kL) would result in an estimated $124,000 per annum fresh water bill for a typical 2000 sow piggery. This would provide obvious incentive for reducing water use by improving water use efficiency and reducing wastage, being an equivalent of about 3 cents/kg sold (based on 1,793 kg sold per sow per year). In general, water use is reduced by conserving water or by treating and recycling water. Australian piggeries do not typically discharge treated wastewater to sewer, because of remote piggery locations typically precluding connections to sewerage reticulation lines. Nutrients and water in treated effluent and sludge is commonly used as a nutrient fertilizer source. For example, the nutrient value of spent piggery litter has been estimated at $31.20/t (APL, 2015) when used locally. The phosphorus concentration in sludge can be comparable to that in spent litter (APL, 2010). However, when transported over significant distances, the value of effluent, sludge (and spent piggery litter) can be low or negative (<$10/t), because of bulk (moisture content) and dilute nutrients relative to synthetic fertilizers (Mehta et al., 2015).

Technologies are commercially available to treat wastewater from piggeries up to an adequate quality for various use purposes (Murphy et al., 2016; Piazza_Research, 2016). Treatment options can range from simple uncovered pond-based systems for recycling flush effluent, through to comprehensive multi-step treatment to prepare water for potable reuse. It is generally good practice to treat water to the quality required for the end-use purpose (e.g. direct contact uses, in-direct uses or irrigation). This is because the required water quality directly affects extent and cost of treatment (Murphy et al., 2016). For example, treatment to reuse piggeries effluent for high rate irrigation use has recently been costed at up to $0.42/kL (Murphy et al., 2016), whilst the more advanced wastewater treatment required for potable reuse in piggeries was costed much higher at up to around $6.9/kL (Murphy et al., 2016). This indicated that advanced wastewater treatment in piggeries for drinking water preparation is likely cost prohibitive. To the authors' knowledge, no piggeries in Australia currently treat wastewater to a potable or direct contact standard, and a regulator enquiry confirmed this (See Section 3.1).

Water can be conserved by up to 30% (APL, 2015). Typical conservation measures include (APL, 2015):

- Monitoring water use to identify potential water leaks;
- Reducing water wastage during pigs drinking by using well-designed bowl drinkers and bite nipples (Alvarez-Rodriguez et al., 2013);

- Using sheds with sandwich panel walls and fully slatted floors;
- Using deep litter with concrete flooring, so that the need for wash-down hosing is minimal.

Many piggeries use recycled treated effluent to flush sheds of manure, thereby saving water without necessarily reducing the total cleaning water volumes (APL, 2015). However, recycling of treated effluent can also exacerbate shed odour, struvite (magnesium ammonium phosphate hexahydrate) and other inorganic minerals can build up in pipelines carrying effluent (APL, 2015), increasing required maintenance.

Future key issues/risks

Into the future, Australian piggeries will likely face increased water stress, requiring additional measures to conserve or recycle water. Whilst, the above existing measures are effective at minimising the current water use, there is concern that, in order to minimise fresh water in-take, piggeries may in the future need to treat wastewater to a higher quality for higher quality end-use purposes. This introduces three key future issues/risks:

1. How will water treatment infrastructure be paid for in the medium term? The brief outline of cost analyses above, suggest that life cycle costs for advanced treatment is up to around $6.9/kL (Murphy et al., 2016), being substantially higher than the cost of fresh water, even at $4/kL. In this, it may be necessary to better understand other associated benefits of treating wastewater to a higher quality, such as pork production benefits and pig health and growth and antimicrobial use. The limited work to date on this topic, is outlined below.

2. What technologies will be suitable for wastewater treatment? Piggeries have unique requirements, for which existing wastewater treatment and recycling approaches are not necessarily tailored. The limited work to date on this topic, is outlined below.

3. There is a potential regulator risk in terms of guidelines and requirements for treated wastewater quality for future applications. As noted above, the extent of treatment dictates the intensity and cost of treatment (Murphy et al., 2016). Suitable treated water quality requirements should aim to minimise risks (e.g. pathogens) whilst at the same time preventing excessive treatment requirements and regulatory restrictions.

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2. Knowledge gap analysis and identification of needs for future research

2.1 Piggeries effluent quality requirements for various water reuse purposes

2.1.1 Recycled water for flushing

To conserve water, recycled or treated effluent is commonly used at Australian piggeries for flushing. There have been very few studies of recycled treated effluent on shed air quality. The use of recycled effluent would probably raise in-shed airborne concentrations of bacteria and ammonia to a significantly higher level than when fresh water is used for flushing (Bolton, 2013). In general, negative impacts on shed air quality are minimised by providing adequate ventilation (APL, 2010).

Very limited available studies have ascribed significant cost savings to animal productivity and health benefits of using higher quality treated wastewater. A cost saving of USD6.13/finished pig (7AUcents/kg live weight, assuming a finishing weight of 121 kg) was estimated by a fairly large USA study conducted in North Carolina aimed at developing environmentally superior waste management technologies (Vanotti et al., 2009). A separate estimate amounted to a productivity loss of AUD684,000/annum for a 2000 sow farrow-to-finish piggery using conventionally treated recycled effluent (Bolton, 2013) (this amounts to 15AUDcents/kg live weight, assuming 2200 kg live weight sold per sow per year). Whilst it would seem reasonable that a higher quality recycled flush water would reduce requirements for in-shed air quality control and reduce shed odour, it could be challenging to resolve production benefits associated with higher quality recycled flush water from other environmental factors that also influence production. However, if the benefits noted immediately above could be substantiated, and could be consistently sustained in a commercial piggery, these may be sufficient to pay for the cost of advanced wastewater treatment. Alternatively, the treatment cost could be reduce by developing cheaper technologies such as the bubble column evaporator (BCE) briefly described in Section 2.2 (Piazza_Research, 2016). Other flow-on benefits that could be considered may include reduced expenses from vet bills, reduced antimicrobial use, and circumventing the cost of disease outbreak scenarios (Bolton, 2013). No studies were found linking water quality and antimicrobial use.

2.1.2 Irrigation water

Piggery effluent contains a high level of organic matter (biological oxygen demand (BOD) > 5000 mg/L; (FSA Environmental QLD, 2000), suspended solids, nitrogen and phosphorus, and a wide variety of micro-organisms, including potential pathogens. Table 4 summarises final pond effluent composition from conventional intensive piggeries, commonly directed towards irrigation for its nutrient value and to improve soil fertility, structure and soil microbial activity (APL, 2010). The application rate of effluent generally depends on nutrient concentration, type of crops and soil characteristics rather than on hydraulic load. Two APL guidelines (APL, 2010; APL, 2015) are available addressing effluent irrigation. Key risks include; applying nutrients in excess of plant requirements, leading to leaching and run-off; odour, when irrigating poorly or partially treated effluent; pathogen risks; and excessive application of salts leading to the degradation of water and soils (APL, 2015). These effects of salinity are dictated by the ratio of sodium (Na) to calcium (Ca) and magnesium (Mg) (APL, 2015).

Table 4. Characteristics of piggery pond irrigation effluent (from (APL, 2010)).

Element	Unit	Effluent at work[a]	DPI data[b] average (range)	DPI data[b] average (range)
Dry matter	mg/L	3623	4458 (1240–12600)	7900 (1100–44300)
Volatile solids	mg/L	1809	1809 (220–4400)	1640 (480–5290)
Total nitrogen or [total Kjeldahl nitrogen (TKN)]	mg/L	[384]	[654 (158–1731)]	584 (158–955)
Total phosphorus	mg/L	44	55.9 (11.0–132.0)	69.7 (19.3–175.1)
Potassium	mg/L	–	616 (97–1845)	491 (128–784)
Sulphur	mg/L	-	22 (9–50)	
Copper	mg/L	–	–	0.09 (0.00–0.28)
Iron	mg/L	–	–	0.56 (0.09–1.61)
Manganese	mg/L	–	–	0.02 (0.00–0.05)
Zinc	mg/L	–	–	0.47 (0.16–1.27)
Calcium	mg/L	–	18 (7–31)	20.6 (7.3–41.2)
Magnesium	mg/L	–	33 (8–108)	25.0 (6.6–72.3)
Sodium	mg/L	603	603 (103–2870)	399 (41–1132)
Chloride	mg/L	810	810 (269–1950)	19.1 (3.6–34.4)

DPI = Department of Primary Industries and Fisheries, Queensland.

[a] (Kruger et al., 1995)

[b] Unpublished data — samples from 10 piggeries in southern Queensland.

In terms of pathogen risk, separation distances between irrigated field and animal grazing (e.g. 125 m at wind speeds of 0.5 m/s and 300 m at wind speeds of 2.5 m/s) are required to minimise risks from *Campylobacter* and *Salmonella* in irrigation aerosols (APL, 2010). Potential health risks from pathogens on animals grazing on pastures irrigated with piggery effluent, are commonly reduced via withholding periods following irrigation (APL, 2015). According to the Australian guidelines for water recycling (NRMMC et al., 2006), pigs must not be fed or exposed to land or fodder crops irrigated with urban sewage-derived recycled water, mostly to limit *Taenia solium* in Australia. *Taenia solium* is the pork tapeworm helminth, and after its ingestion might cause human neurological symptoms, including epileptic seizures, when entering the central nervous system. South Australia Environment Protection Authority (SA EPA) also has specific mention of a minimum 25 days' detention time to minimise infection risk of cattle and pigs by tapeworm helminths (EPA, 2005). A 21 day withholding period is stipulated in the Piggery Manure and Effluent Management and Reuse Guidelines, together with a number of practical methods to minimise pathogen risks with irrigated effluent (APL, 2015).

2.1.3 Pig drinking water

Water is an essential element in pig nutrition. It is known that the quality of the drinking water has an impact on the growth and development of the pigs. Pathogens potentially present in Australian piggery effluent may affect human health including *Campylobacter*, *Salmonella*, *Erysipelothrix* and *E. coli* (Chinivasagam et al., 2004). Rotavirus has been noted to be ubiquitous in Australia and causes pig disease, but generally does not cross the species-host barrier (APL, 2010). Table 2 below summarises drinking water quality for optimal pig health. Currently, there is no standard for pig drinking water reusing piggery effluent. From Table 2, pigs appear to require a lower quality drinking water than humans. An interesting study conducted by North Carolina State University (Bull, 2003) evaluated the use of recycled piggery effluent for pig drinking water by treated lagoon wastewater filtered (<10 micron filter) followed by chlorination (1 mg/L residual chlorine). There was no evidence of any performance reduction or other adverse animal responses to the inclusion of a significant portion of recycled treated wastewater (of an appropriate treated quality) as drinking water.

The use of high quality pig drinking water could also improve the efficacy of medicinal treatments dispensed via drinking water. This may provide incentive for treatment of extracted groundwater currently used as drinking water at a piggery.

Table 5. Comparison of water quality standards for pig drinking water around the world and the Australian Drinking Water Guidelines (ADWG).

Characteristic	Australia[a]	Unated State[c]	the Netherlands (no risk)[c]	Canada (Max.)[c]	ADWG[d]
pH	6.5 – 8.5	6.5 – 8.5	5 – 8		6.5 - 8.5[e]
Ammonia (mg/L)			< 1		0.5[e]
Nitrite (mg N/L)	9	< 10	< 0.1	10	3
Nitrate (mg/L)	90	< 300	< 25	100	50
Chloride (mg Cl/L)		< 250	< 250		250[e]
Iron (mg Fe/L)	Below toxic levels		< 0.2		0.3[e]
Manganese	Below toxic levels		< 12		0.5
Sulfate (mg/L)	1000	< 2650	< 100	1000	250[e]
Calcium (mg/L)	1000			1000	
TDS (mg/L)	< 1000[b]	< 1000		3000	600[f]
Thermotolerant coliforms (CFU/100mL)	100	< 50			Not detected
Microcystis (cells/mL)	11,500				1.3 µg/L

TDS: Total Dissolved Solids.

[a] (ANZECC & ARMCANZ, 2000).

[b] ideal TDS level according to (Government of Western Australia Department of Agriculture and Food, 2017).

[c] (https://projects.ncsu.edu/project/swine_extension/publications/factsheets/811s.htm)

[d] (NHMRC & NRMMC, 2011).

[e] ADWG aesthetic limits.

[f] TDS < 600 mg/L is considered as good, TDS > 1200 is considered as unacceptable (unpalatable).

Potable water for human consumption is increasingly being sourced through alternative sources such as treated wastewater. The standard for human water consumption in Australia is referred to the Australian Drinking Water Guidelines (ADWG) (NHMRC & NRMMC, 2011). These provide health and aesthetic guideline trigger values, and highlight that the greatest risks for consumers of drinking water are pathogenic microorganisms. The Australian guidelines for water recycling (AGWR) generally follow the ADWG, with the exception that the AGWR uses a disability-adjusted life year (DALY) to determine requirements for pathogen removal for a specific end-use purpose. DALY is a common metric for all types of hazards taking into account health outcomes including probabilities, severities and duration of effects (WHO, 2011). From this factor and the assumed concentration of a specific pathogen in the source wastewater being treated, a required log removal value (LRV) is calculated (NRMMC et al., 2008). LRV is a way to express removal or inactivation efficiency for a target contaminant such as a pathogenic microorganism or a surrogate (1 LRV = 90% reduction in density of the targeted contaminant, 2 LRV = 99% reduction, 3 LRV = 99.9% reduction, and so on) calculated using Equation 1.

$$LRV = \log_{10}(\frac{C_{in}}{C_{out}}) \qquad \text{Equation 1}$$

where C_{in} and C_{out} are concentrations of pathogens in the raw and treated water, respectively. According to the AGWR, typical LRV of pathogens are to be (NRMMC et al., 2008):

- 9.5 LRV for viruses (using a combination of rotavirus and adenovirus for enteric viruses);
- 8 LRV for protozoa and helminths (using *Cryptosporidium parvum*);
- 8.1 LRV for bacteria (using *Campylobacter jejuni*).

Following this methodology, Stevens et al. (2017) used a quantitative microbial risk assessment (QMRA, which identifies hazards and risks) to establish a log removal target required for helminth egg. As a result, a 3 LRV of helminth egg in raw sewage is required to achieve the health based target of 1 µDALY (equivalent to < 2 cases/day for a city of 1 million people) to protect human and pig health with the use of recycled water in countries with low *Taenia* risk, such as Australia.

Antibiotic resistance gene and bacteria have been identified as emerging contaminants that may present environmental and public health concerns, and they might be present in piggeries effluent. Antimicrobial resistance is the ability of a microorganism to stop an antimicrobial (such as antibiotic) from working against it, and it has reached alarming levels in many parts of the world (WHO, 2014). For this reason, the World Health Organisation (WHO) has launched guidelines on the use of antimicrobials in food-producing animals (WHO, 2017). However, the current water reuse regulations and guidelines do not adequately address this issue. As a result, the fate of antimicrobial resistance via wastewater treatment and in irrigated soils is topics of active research (Hong et al., 2018; McLain & Williams, 2014).

2.1.4 Research Gaps

In general, there is a need to clarify effluent quality requirements for various reuse purposes at Australian piggeries, including for:

a) current base case of irrigated effluent and treated wastewater recycling for flushing; and
b) the future quality requirements for pig drinking water reuse.

Water quality and reuse requirements should also consider public perception and public ethics. Communication about water quality requirements should actively prevent misconceptions/perceived impacts, thereby preventing excessive regulatory restrictions on wastewater treatment and recycling/reuse.

In general, relevant stakeholders and regulatory authorities should be consulted when developing wastewater treatment and recycling initiatives, which may extend to international stakeholders for pig meat exports.

2.2 Wastewater treatment technologies

Table 3 summarises and briefly evaluates existing treatment technologies, which may also be used to treat pig effluent to various degrees. Overall, there are multiple treatment options commercially available on the market.

Table 6. Summary of treatment technologies used in water recycling.

Technology	Removal mechanism	Contaminant removal	Advantage	Disadvantage	Readiness
Pre-treatment					
Coagulation/ flocculation	Electrostatic Adsorptive Precipitation	Turbidity Suspended particles Colloidal Dissolved organic matter	Good pre-treatment. Low maintenance	Chemical cost (coagulant + pH regulation)	Established in drinking and recycled water treatment
Sand filtration Particle size cut-off from 0.45 mm	Size exclusion	Protozoa Bacteria Turbidity Colour Taste Odour (for some) Organic matter (only biofiltration)	Low capital cost Low maintenance	High footprint for slow sand filtration (SSF)	Well established in drinking water treatment

Technology	Removal mechanism	Contaminant removal	Advantage	Disadvantage	Readiness
Pre-treatment					
Ion exchange resin	Charge attraction	Taste Odour Organic matter	Low maintenance	Expensive to build and to replace resin Brine disposal. Not effective for high-strength waters	Used in the USA water treatment.
Membrane Bioreactors (MBR)	Biological + Size exclusion	Protozoa Bacteria Virus Turbidity	Low footprint. Low capital cost. Very stable. Produces good treated water quality	Moderate to high operating costs related to membrane replacement and fouling	Well established
Membrane filtration system					
Micro filtration (MF) Particle size cut-off > 0.05 – 10 μm	Size exclusion	Protozoa Bacteria Turbidity	Low energy Small footprint	High chemical cleaning cost due to fouling High maintenance	Well established in drinking and recycled water treatment
Ultrafiltration (UF) Particle size cut-off > 0.01 – 0.05 μm	Size exclusion	Protozoa Bacteria Some virus Colloids	Low energy Small footprint	High chemical cleaning cost due to fouling High maintenance	Well established in drinking and recycled water treatment
Nanofiltration (NF) Size cut-off > 0.001 – 0.01 μm	Size exclusion Charge repulsion Diffusion Adsorption	Protozoa Bacteria Viruses Some ions Turbidity	Small footprint Good removal using less energy than RO	Sensitive to chlorine. High chemical cleaning cost High fouling rates	Well established in drinking and recycled water treatment
Reverse osmosis (RO) Size cut-off < 0.002 μm	Size exclusion Charge repulsion Diffusion Adsorption	Protozoa Bacteria Virus Many ions Colour Organic matter Odour Heavy metal Turbidity	High removal efficiency Produce high quality water Low surface space <0.1 m3 per day systems available, potentially suitable for	High energy consumption Sensitive to chlorine High chemical cleaning cost. High fouling rates: Pre-treatment necessary	Well established in drinking and recycled water treatment

Technology	Removal mechanism	Contaminant removal	Advantage	Disadvantage	Readiness
Pre-treatment					
			piggeries (Piazza_Research, 2016)	High maintenance **Concentrated brine disposal**	
Forward osmosis (FO)	Osmosis gradient	Protozoa Bacteria Virus Colour Organic matter Odour Heavy metal Turbidity Salt	Low energy consumption. Work with dirty water.	Lower water flow than RO Not as competitive as RO Emerging Industrial acceptance	Not as widely Emerging technology
Disinfection system					
Chlorination	Inactivation	Bacteria Virus Colour	Cost effective. Low maintenance.	Does not remove/ inactivate protozoa. Formation of disinfection by-products in presence of organic matter. Long residual chlorine. pH dependent.	Well established in drinking and recycled water treatment
Ozone	Oxidation	Protozoa Bacteria Virus Organic matter Taste Odour Colour	Short residual effect.	Complex technology. High maintenance. Aggressive odour.	Well established in drinking and recycled water treatment
UV	Irradiation	Bacteria Virus	Short residual effect.	Not effective in excessively turbid or coloured waters.	Well established in drinking and recycled water treatment

Table 4 shows a high-level estimated cost to produce water for irrigation and pig drinking water, based on existing projects. It is clear from the data in this table that the investment associated with advanced water treatment is significant.

Table 7. Indicative capital costs.

Technologies	Capital costs
UF + RO + UV	\$1.4 M[a]
DAF + MBBR + DAFF + UF + RO + UV + chlorination	\$15 M[b]

DAF = Dissolved Air Flotation; DAFF = Dissolved Air Flotation and Filtration; MBBR = Moving Bed Biofilm Reactor; RO = Reverse Osmosis; UF = Ultrafiltration; UV = Ultraviolet.

[a] Based on cost estimate for 0.2 ML/d of raw water to the UF, which is the estimated flow for a 3000 sow farrow to finish piggery (Murphy et al., 2016). Note, would likely require upfront aerobic treatment to reduce carbon in raw water to UF and thus minimise membrane fouling.

[b] Cost from Yatala Brewery (Hertle et al., 2009). Plant built in 2004 to produce up to 2 ML/d high quality potable water. Cost includes all approvals, planning, design and construction of the plant and integration of recycled water and biogas into a brewery.

In order to address cost and practical operation and complexity issues with existing water treatment technologies, an APL project invested in the initial evaluation of a novel Australian technology called the bubble column evaporator (BCE) (Piazza_Research, 2016). Suggested advantages of this new technology included:

1. Mechanical simplicity, not requiring extensive technical support.
2. Scalable for both smaller and larger producers.
3. Relatively low setup and operational costs, as compared to alternatives.
4. Producing potable water.

When the financial business case for wastewater treatment and recycling in general has been established, and water quality requirements have been confirmed, then treatment approaches mentioned above should be considered, giving consideration to cost benefit within pork industry-specific constraints.

3. Research

3.1 Regulators' perspective

Key industry service providers and regulators were consulted about current activities in water recycling in the pork industry and the regulatory framework relevant to wastewater treatment and recycling in piggeries. This was done to better understand relevant developments and the likely regulatory framework for future wastewater treatment and recycling project at piggeries. Questions asked were:

1. Without mentioning names or locations, are you aware of any pig farms in your State that is treating wastewater up to a potable standard for reuse?
2. If you were approached by someone with a plan to treat piggery wastewater to a potable standard for reuse, which water quality guidelines and regulations would you revert to for this application?
3. If a piggery approached you with a plan to send piggery wastewater to a third-party site for irrigated crop growth, which water quality guidelines and regulations would you revert to for this application?
4. Are you aware of any research in your state on the broader topic of treating and recycling of agricultural wastewater for various uses? Are you aware of any research in your state specifically on treating and recycling wastewater from livestock production? If so, which groups/institutes are conducting this research?

3.1.1 NSW: Robert Mitchell

Principal Technical Assessor – Water - Lands & Water, Department of Industry. Contact via Ms Jayce Morgan - Development Officer Pigs - Intensive Livestock Industries; Agriculture NSW; Department of Primary Industries

Response (paraphrased) - I don't believe that potable reuse has been considered for piggery wastewater. I would think there would be a lot resistance from regulators and also the public. In regards to guidelines for preparation of pig drinking water - Australian Guidelines for Water Recycling 2006. In regards to regulations for preparation of pig drinking water - Various depending on who is running the water supply, relevant health legislation and so on. In regards to use of effluent by irrigation, the relevant guideline is Use of effluent by irrigation (NSW EPA) & Australian Guidelines for Water Recycling 2006, and in regards to the regulations dictating effluent to irrigate third-party crops, the Protection of the Environment Operations Act 1997 is relevant, and this is assuming that the piggery is a scheduled activity and licensed. The effluent reuse for irrigation may be included in the licence in terms of use and application area. The 3rd party may require a separate licence depending on the scale and size of the reuse. Other planning and approvals as required under the Act. I'm not aware of (any) research (on the stipulated topic).

3.1.2 NSW: EPA Peter Marczien

Response (paraphrased) - Not aware of any piggeries reusing piggeries effluent for pig drinking water. Will need to consult health department and agriculture agency. Will need to do a risk assessment and the response that may come from the health department and agriculture agency may not be clearly interpretable, especially if mentioning *Taenia* risk. However, some people could be open to the idea of wastewater treatment and recycling. The Health and agriculture departments should be involved in early stage of water recycling project.

3.1.3 QLD: Mitchell Furness

Manager, Environmental Regulation - Animal Industries, Department of Agriculture and Fisheries. Contact via Mr. Alan Skerman - Principal Environmental Engineer, Agri-Science Queensland, Department of Agriculture and Fisheries.

Response (paraphrased) – No, I am not aware of any pig farms in QLD treating wastewater up to a quality for direct contact uses, including potentially potable standard for pigs? Feedlots are known to reuse recycled wastewater for wash down of cattle, and abattoirs in some instances treat wastewater for re-use. In regards to guidelines and regulations - Possibly (the) following? - Technical guideline QDEHP ESR/2015/1654 Version 2.00, Effective: 12 SEP 2016 ABN 46 640 294 485 Licensing Wastewater release to Queensland waters; Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Australian and New Zealand Environment and Conservation Council – ANZECC, 2000); Australian Drinking Water Guidelines (2011) – Version 3.4 Updated October 2017; EPP (Water) 2009; Waste Reduction and Recycling Act 2011; APL NEGP Guidelines 2018.

3.1.4 VIC: Robyn Tucker

Principal Consultant – Livestock Environmental and Planning

Response – EPA and water boards e.g. GM Water (and sometimes catchment management authorities, or CMAs) can all have a role in regulating water reuse for Victorian piggeries. However, EPA will take the most interest, because the water boards and CMAs would likely be more interested in preventing stormwater contamination and to enforce buffers from waterways. The EPA seem to be progressively targeting more stringent treatment of piggery effluent, for example, wanting piggeries to install additional effluent treatment ponds before wet weather storage, with surface area-based loading rates on the secondary pond. This means that when any piggery with a two-pond system wants to expand over 5000 head, anyone with a two-pond system or a smallish facultative pond would generally need to put in an extra pond / expand their secondary pond. As far as I know, there are no piggeries that are treating wastewater up to a quality for direct contact uses, including potentially potable standard for pigs. EPA has a new Works Approval guideline for piggeries, which may be relevant in regards to third party reuse: https://www.epa.vic.gov.au/~/media/Publications/1686.pdf.

3.1.5 WA: Portec,

A veterinary consulting company – Response by anonymous officer

Response (paraphrased) – I'm not aware of any piggeries doing water recycling except for manure flushing. However, in my opinion, water recycling for pig drinking water should be feasible if the water quality is demonstrated, particularly as helminth could be an issue. State and/or council regulations should be followed for irrigation. Portec is not aware of pig wastewater recycling research in WA.

3.1.6 TAS: Department of Primary industries, Water and Environment (DPIPWE) and EPA

Response (paraphrased) - Pig production in Tasmania is small, so we have not come across previous requests for information on the reuse of piggeries effluent, and we are not aware of any research on agricultural wastewater recycling. The DPIPWE person was interested in reuse of urban biosolids for agriculture, and had mentioned that it was important to know the survival of helminth in effluent to determine adequate treatment.

4. Discussion

This enquiry confirmed that piggeries in Australia are not currently treating effluent for recycling to high-end uses, including potable reuse. This is perhaps not surprising, given the current high cost of advanced treatment, uncertainty over the anticipated benefits, and uncertainty about the suitable treated water quality. The regulatory framework is likely to differ between different production states of Australia, but some consistent guidelines appear to be consistently emerging, primarily based on water production for human consumption. These guidelines may be excessive for pigs and needs further clarification.

5. Recommendations

Based on the findings above, the following research projects/research directions are recommended:

5.1 Understanding the relationship between recycled water quality and production performance factors such as pig health and growth and antimicrobial use.

This could be expanded to understand the true risks (e.g. pathogens and other) associated with irrigating treated effluent, and effects of treated recycled flush water quality. The purpose is to better understand opportunities, and to ensure that future regulatory requirements are effective and not excessive for reasonable applications.

Proposed project scope: The relationship between water quality and antimicrobial use is not well understood. This work should clarify the impact of recycled flush water quality on production benefits likely to pay for future wastewater treatment and recycling initiatives. There is also a need to understand how wastewater treatment can influence antimicrobials and antimicrobial resistance, to identify risks and opportunities gained from wastewater treatment. Lastly, it would be important to track contaminants, including but not limited to nutrients, salinity, pathogens and emerging micro-pollutants of concern. This is especially important in light of the emerging interest in anaerobic co-digestion, whereby a piggery is paid to receive and treat wastes from other industries in a covered pond or digester. Wastes from other industries being co-digested with pig manure, may carry nutrients influencing nutrient management plans, and may contain recalcitrant contaminants such as heavy metals, pesticides, pathogenic loads, and/or other non-biodegradable toxicants. The risk of such contaminants should be better understood to provide clear guidance to pork producers wanting to co-digest other wastes together with pig manure.

5.2 Clarifying guidelines and requirements for treated wastewater quality for the applications of effluent irrigation, whether at the piggery or at third party sites, and for wastewater treatment for recycling and reuse within piggeries.

Proposed project scope: The development of a wastewater treatment and recycling guideline would provide clarity for future updating of the National Environmental Guidelines for Piggeries, and a clear reference point for future water treatment and recycling projects. Such a guideline would also prevent excessive treatment requirements, by matching the true risks and benefits with the treated water quality required. This future research may also develop a fast and robust detection method for *Taenia solium* or surrogate measures, in support of the guidelines.

5.3 Development of cost effective water conservation methods, and wastewater treatment and recycling approaches for piggeries.

Proposed project scope: This research would progress water conservation and wastewater treatment and recycling options, supported by cost benefit analysis (CBA) and being sensitive to practical and economic feasibility constraints in the Australian pork industry (Murphy et al., 2016) to provide clarity to Australian pork producers evaluating various options.

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