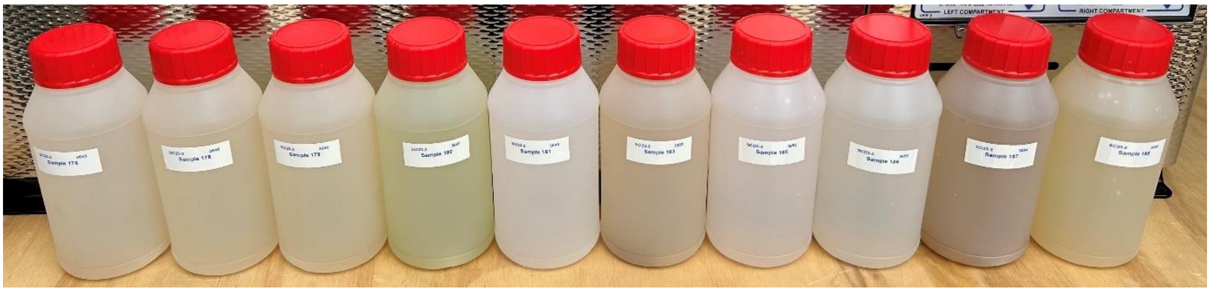
A case study: assessing the quality of source water fed to pigs in Western Australia

Final Report



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Disclaimers

Acknowledgements

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Executive Summary

The suitability of water for pigs in all production phases depends somewhat on the soluble salts present in it. Hence, salinity of the water they drink is an important property affecting water consumption. Pluske *et al*. (2006) found that small increases in water use, due to, for example, a high salt level and (or) the price associated with water treatment, decreased overall piggery financial viability. Western Australia (WA) has the largest underground salt, predominately chloride (Cl) and sodium (Na), reserves in Australia (Sexton, 2003), resulting in the corresponding groundwater being saline to some degree. The TDS (total dissolved solids) content is often used as a proxy to represent salinity with the generally recommended safe level in water for pigs being less than 3,000 mg/L (DPIRD 2021). Edwards and Crabb (2021) found that Cl and Na were among the most common water parameters to exceed the acceptable standard (250 mg/L and 150 mg/L, respectively) in source water fed to pigs. They also noted that excess Cl and Na can cause increased water intake, can affect the gut microbiome, and importantly impact the activity of some antibiotics delivered via the water. In addition they listed additional compunds and elements that contribute to TDS in water such as sulphate, nitrite, iron, magnesium and manganese, that may be of concern.

The aims of this Project were to assess the seasonal and yearly variability of locally sourced water used by a broad representation of WA piggeries for key water quality parameters, including salinity, that can potentially impact pork production in the State; evaluate portable on-farm water quality meters for rapid assessment of key water quality parameters; and disseminate the findings and possible implications to WA pork producers.

During four time periods in year 1 of the Project, 31 samples were collected from 19 sites across Western Australia. During the second year, 32 samples were collected from the same sites during three time periods. A total of 220 samples were collected and tested for TDS, Cl, Na and nitrite according to standard procedures at the Marine and Freshwater Research Laboratory, Murdoch University (a NATA-accredited laboratory, Accreditation Number: 10603; ISO/IEC 17025:2017). All participants in the study received their own test results as they became available in each period.

As the water samples were taken from sources that are used to feed pigs, it is understood that if it was possible, a producer may have changed the make-up of this water to benefit their animals. Hence, comparing samples across time was not reliable but still provided some indication that there was possibly a seasonal influence and quite likely that water content is different between the various regions. Nevertheless, analyses within samples were reliable with indications that most water samples had more man 50% Cl and Na but other elements also had some importance.

This finding is interesting for producers using on-farm water meters that measure TDS because it provides a general indication as to what makes up TDS. The three meters tested in this Project were the *Eutech pocket PCSTester 35 pH/Cond/TDS/Sal/Temp*, the *AD11 pH/Temp/ATC Pocket Tester (0.1 Res)* and the *AD32 EC/TDS/Temp Hi Range Tester 1 – 20MS/ 1-10PPT*. Findings from this Project suggested that all provided reliable results.

A key finding in this Project was the disparity between TDS, Cl and Na levels in water and the recommended accetable levels for each, for pigs. The majority of samples had a TDS level below the accepted standard level of 3,000 mg/L. However, only a third of samples had an acceptable standard level of Cl and Na. Hence, it may be concluded that the generally acceptable level for TDS is not a good proxy for the acceptable level of Cl and Na found in water sources fed to pigs in WA. As producers have ready access to TDS meters but not Cl and Na testing, it is important that they have a good

understanding of TDS in terms of the inorganic salts that comprise their TDS measurement. In addition, determining the relationship between Cl and Na in the feed and water offered to pigs could ultimately enhance piggery financial viability. An abstract based on findings from this Project was accepted for presentation at the 2023 Australasian Pig Science Association (Inc) Conference and will further enhance this discussion.

As an extension to this Project, PIWA has been successful in attaining funding from the Federal Government's Extension and Adoption of Drought Resilience Farming Practices Grants Program. The Project, *Managing water in a changing climate - An extension toolkit to facilitate adoption of best practice water management for pork and poultry producers in Western Australia*, will enable factsheets and info notes pertaining to the findings from this Project to be written and extended to producers in Western Australia.

The following outcomes were achieved from this Project:

a) Water test result summaries sent to project participants after each sampling round;
b) A summary of key points from this Project available for all pork producers in Western Australia;
c) A conference abstract detailing specific findings from this Project to be presented at the 2023 Australasian Pig Science Association (Inc) Conference, November 2023;
d) A sucessful grant application to facilitate extension activites associated with the findings from this Project.

It is recommended that further work be conducted to examine the relationship between Cl and Na levels in water and in feed on case sites where high levels of Na and Cl were recorded. This is because total Na and Cl intake could be impacting production health and economic viability of piggeries in WA.

Contents

1. Introduction

Water, the 'forgotten nutrient', is essential for pigs, must be drinkable, should not contain harmful substances, high numbers of coliforms or excess concentrations of some elements, and be readily available and provided in a form to allow for survival and optimum health and production (Menegat *et al*., 2019). Generally speaking, the suitability ('quality') of water for pigs in all production phases depends somewhat on the soluble salts present in it, hence salinity of the water is a very important property affecting water consumption (National Research Council; NRC, 2012). The dissolved minerals most commonly contain chloride, sodium, sulphate iron, magnesium and manganese, and are expressed commonly in TDS (total dissolved solids) units. TDS can be used to represent salinity. The recommended maximum TDS level in water fed to pigs is 3,000 ppm (3,000 mg/L) (from the NRC, 2012). There is evidence that pigs drinking water with a high TDS (> 4,000 ppm) can suffer from diarrhoea and levels exceeding 7,000 ppm are considered unfit for consumption (NWQMS, 2000; NRC, 2012). Furthermore, excess sodium and chloride can cause increased water intake, can affect the gut microbiome, and importantly impact the activity of some antibiotics delivered via the water (Edwards and Crabb, 2021). Some changes in diet formulation may also be warranted with a changing water salinity, i.e., reducing or omitting the salt in the diet in the case of a high TDS concentration. However, without measuring the TDS in water and its variation over time, important decisions such as this cannot be made.

Other factors such as pH and nitrites may also impact water quality and have adverse consequences for pork production. The pH of water per se, probably has little direct relevance to water quality, but variations in pH can exert major effects on chemical reactions involved in the treatment of water, should that be practiced on farms. High water pH impairs the efficiency of chlorination for example, whilst low pH may cause precipitation of some antibacterial agents delivered via the water (NRC, 2012). Furthermore, the conversion of nitrates, which can be found in areas with large nitrogenous fertilizer application or runoffs, to nitrites in water (e.g., with bore water), can cause toxicity in pigs under some circumstances (NRC, 2012).

Some guidelines exist for water quality for livestock including pigs, e.g., NWQMS (2000), NRC (2012) and DPIRD (2021a). Nonetheless, these are very broad recommendations, and the fact remains that despite its overwhelming importance to pork production and health, there has been limited objective research conducted on water quality and its variability for pigs (Epp, 2019; Edwards and Crabb, 2021). Edwards and Crabb (2021) conducted a survey of water quality across 57 pork production enterprises around Australia. They concluded that in general, pork producers don't routinely test their water or know of the potential negative impacts that poor-quality water might be having on production or the economics of their business. They also concluded that the source water was likely to contain sodium and chloride (salt; NaCl) in quantities higher than the standard. However, only four piggeries from Western Australia (WA) participated in this study, which is a very small sample size, and the origin of those farms (e.g., whether indoor, outdoor, deep-litter, free-range) and the source of water (e.g., scheme, bore) is not specifically described (due to confidentiality). Furthermore, these samples were only taken in a narrow timeframe (October 2017 to March 2018), and therefore the seasonal and year-to-year variation in key water quality parameters for WA pork producers is not known.

Pluske et al. (2006) found that small increases in water use, due for example to a high salt level and (or) the price associated with water treatment, decreased overall piggery financial viability. Given that WA has the largest underground salt reserves in Australia (Sexton, 2003), that rainfall in southwest Western Australia since 2000 is around 30% lower than the average from 1900 to 1969 (BOM 2020), and that there is considerable interest in technologies such as desalination and reverse osmosis to secure water supplies for agricultural production (DPIRD 2021b), then it is timely to conduct a thorough and more broad assessment of water quality for pork production in WA and its potential implications for the Industry.

The overarching aim of this project was, for the first time, to sample locally sourced water used by WA pork producers' representative of the different production systems (e.g., indoor, outdoor-bred, free-range, deep litter) in WA to assess seasonal and yearly variation in key water quality parameters, including salinity, with the possible implications. An ancillary aim of this project was to examine the use of a portable water quality meters that could be used on-farm to test for several the key water quality parameters.

2. Aims

Aim 1: Assess the seasonal and yearly variability of locally sourced water used by a broad representation of WA piggeries for key water quality parameters, including salinity, that can potentially impact pork production in the State.

Aim 2: Evaluate portable on-farm water quality meters for rapid assessment of key water quality parameters.

Aim 3: Disseminate the findings and possible implications to WA pork producers.

3. Methodology

a) Selection of study farms, sample collection

With the assistance of WAPPA, in January 2022, five production sites were recruited in the northern agricultural area (North) five production sites in the eastern agricultural area (East), and six production sites in the southern agricultural area (South). In addition, three sites were selected in the central region (Central) (Figure 1). This number was slightly more than what was planned, 19 compared to 16, but enabled a wider representation of producers. All producers invited accepted the opportunity to participate in the study.

Figure 1: The sample areas in the Western Australian agricultural zones.

In Year 1 (2022), 31 water samples were collected from across these sites in January, May, August and October resulting in a total of 124 samples. These times broadly represent summer, autumn, winter and spring to enable a potential examination of the impact of season on the assessments of the key water quality parameters.

In Year 2 (2023), 32 water samples were collected in January/February, May and September, broadly representing summer, autumn, winter/spring, resulting in a total of 96 samples (220 in total). The reason for the change in sampling periods from four to three was that a seasonal variation of key water quality parameters, including salinity, was not significantly significant (see Appendix 1). Moreover, above average rainfalls were recorded for the winter of 2023 and so it was deemed unlikely that a seasonal pattern would eventuate in the two years selected for this study.

For all collections, two samples from each source were collected with one sent to the laboratory for analysis and the other tested in the field using hand-held equipment. Filtering of some samples was required in the field. Due to COVID-19 restrictions and general biosecurity requirements, each sample was collected from the source(s) by the producer. Despite lifting of COVID-19 restrictions during the Project, this procedure was followed through until the end of the Project.

b) *Field data*

In the field, all samples were tested for pH, TDS and conductivity using three different portable meters suitable for on-farm testing of water samples.

As pH should be analysed within 7 hours of the sample being collected, this was done in the field. Figure 2 is a photo of the pH meter, AD11 pH/Temp/ATC Pocket Tester (0.1 Res) (AD11) that was purchased at the beginning of the Project from the Perth Scientific Company, Malaga, WA. It was calibrated before each collection period and readings for pH and temperature were taken for each sample.

Figure 2: A photo of the AD11 pH/Temp/ATC Pocket Tester (0.1 Res)

A portable multi-parameter meter, Eutech pocket PCSTester 35 pH/Cond/TDS/Sal/Temp (Eutech) was purchased from the Perth Scientific Company, Malaga, WA, at the beginning of the Project (see Figure 3 for photo). It was calibrated before each collection period. As pH testing was only done in the field this meter was also used to test the pH and temperature of all samples. In addition, readings for conductivity, TDS, and salinity were taken at each collection site.

Figure 3: A photo of the Eutech pocket PCSTester 35 pH/Cond/TDS/Sal/Temp

A simple portable meter, AD32 EC/TDS/Temp Hi Range Tester 1 – 20MS/ 1-10PPT (AD32) was purchased from Perth Scientific Company, Malaga, WA, for use from October 2022 (see Figure 4 for photo). It was calibrated before each collection and readings for conductivity and TDS were taken at each collection site.

Figure 4: A photo of the AD32 EC/TDS/Temp Hi Range Tester 1 – 20MS/ 1-10PPT

c) Laboratory data

All water samples were tested at the Marine and Freshwater Research Laboratory (MAFRL) at Murdoch University. This is a NATA-accredited laboratory (Accreditation Number: 10603) and is also ISO/IEC 17025:2017. Due to some analyses needing to be completed within 24 hours of sampling, samples were delivered to MAFRL at the conclusion of each collection.

All samples were tested for key water quality parameters including TDS, nitrite (NO_2), chloride (Cl) and sodium (Na). Samples were assessed for sulphate (SO_4) in collections 2 and 7 and for conductivity, salinity, total alkalinity ($CaCO_3$), calcium (Ca), iron (Fe), potassium (K), magnesium (Mg), manganese (Mn) and selenium (Se) in collection 7.

d) *Evaluation of water quality parameters*

Water quality parameters were assessed using Analysis of Variance (ANOVA) (2-factor without replication) for geographical, seasonal and yearly variation by comparing TDS readings for each production site. Additional ANOVA (single factor) were completed to determine the influence of Cl, Na and NO_2 on TDS for all samples. The Pearsons correlation coefficient (R) was found to determine the relationship between each with TDS. These analyses were extended for samples from collection 7 to include the additional elements.

e) *Evaluation of portable on-farm water meters*

Data for pH obtained from the AD11 were compared with that collected from the Eutech for all collected samples. Data for TDS and conductivity collected from the Eutech and AD32 meters were compared with that analysed in the Laboratory for collected samples. In addition, data from each of the meters were compared.

f) *Acceptable levels for TDS, Cl and Na*

Analyses were completed to determine the portion of samples that fell into the safe levels for water fed to pigs. Values for TDS, Cl and Na were arrayed for each sample.

4. Results and discussion

a) *Evaluation of water quality parameters*

The results for TDS generated from the laboratory analyses are presented in Figure 5. It must be noted that data from all samples were included in this analysis including those from treated water sources. From the raw data, it can be observed that there is little variation in TDS for samples taken from the North and Central regions. However, there was variation in TDS for samples taken from the East and South regions.

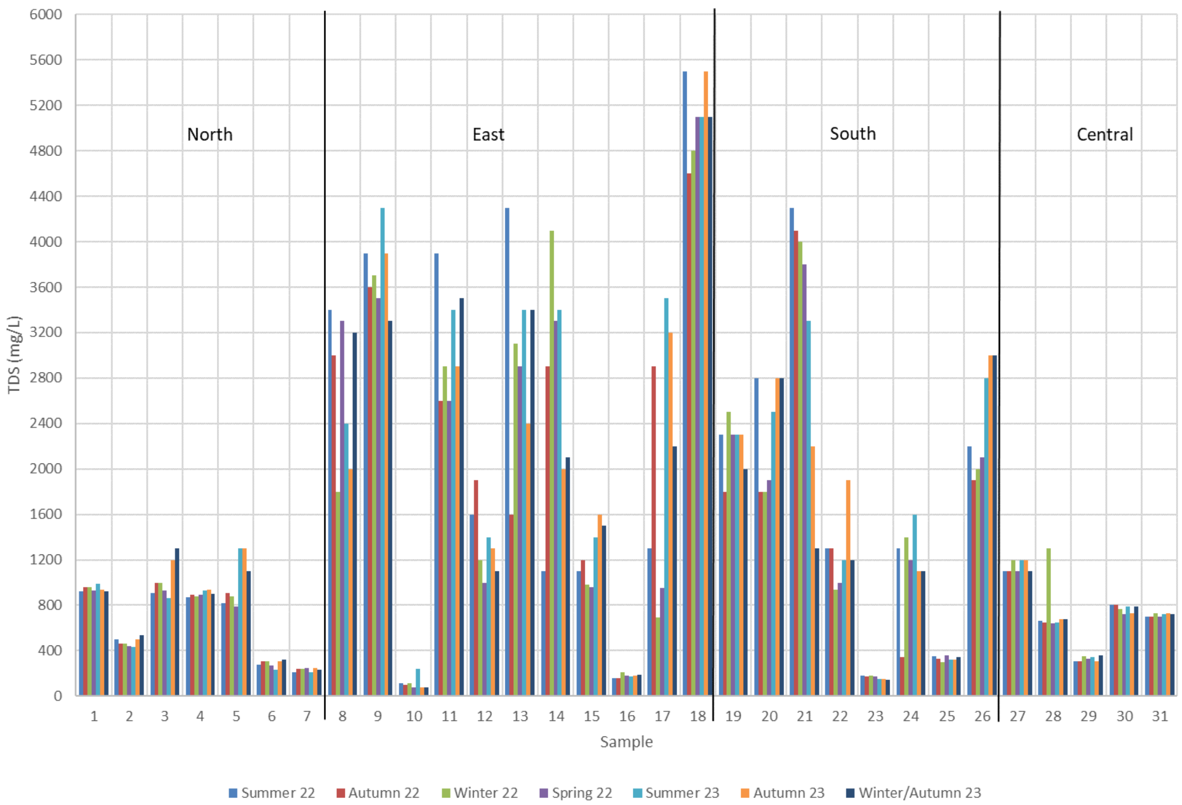

Figure 5. The TDS generated from the laboratory analyses for samples collected throughout the Project

To further investigate the significance of possible yearly, seasonal and regional effect on TDS, ANOVA (two-factor without replication) analyses of these observations were completed. When assessing the effect of region and year on TDS, results indicated that year did not have a significant effect on TDS ($P=0.206$). However, region had a significant effect ($P<0.05$) with the mean TDS values for the north and central regions being lower than those for the east and south (Figure 6).

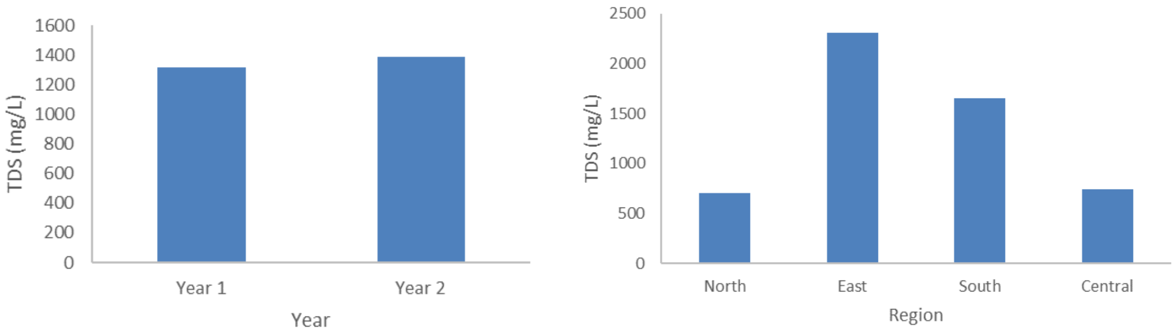

Figure 6 : Mean TDS values generated from the laboratory analyses for water samples collected over the two year period in each of the four regions.

Likewise, results suggested that season did not have a significant effect on TDS ($P=0.215$) (Figure 7). However, as illustrated in Figure 7 and based on Year 1 results, there is a possible trend for TDS to be higher in summer than winter.

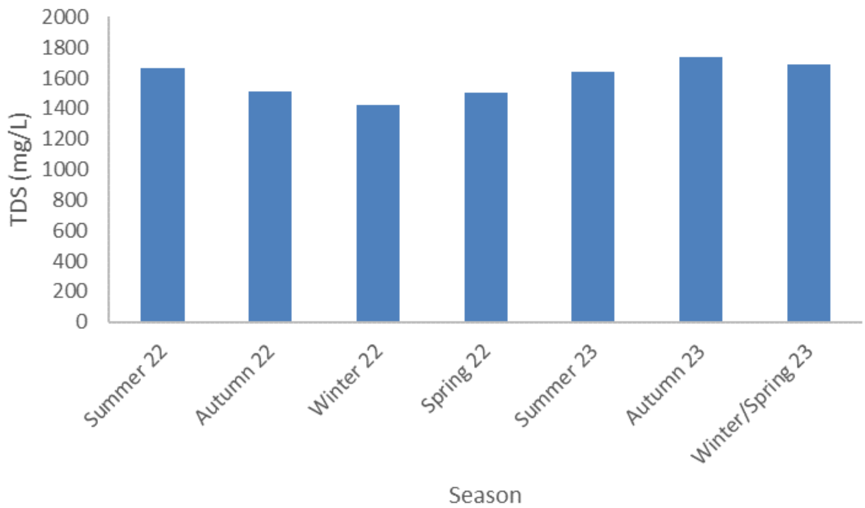

Figure 7: Mean TDS values generated from the laboratory analyses for water samples collected over the seasons

Even so, it is recognised that as producers received their confidential water analysis results after each collection period (see Appendix 2 for details), it would have been rational for those who were able, to improve their water quality. As a consequence, yearly and seasonal variation could not be reliably assessed in this project.

Nevertheless, it was possible to reliably assess the chemical analysis of each sample. The TDS values obtained from the laboratory analyses were correlated with the corresponding Cl (R=0.993) and Na (R=0.984) values. There was also a positive correlation (R=0.988) between Cl and Na.

Combining the values for Cl and Na for each sample and comparing the resulting value with the corresponding TDS value provides an indication of the significance of each as factors of TDS. Despite 90% of the total sample (n=220) having at least 50% of the TDS value (mg/L) made up of Cl and Na, and more than half of samples having at least 75% Cl and Na, it was found that the combined value of Cl and Na did not significantly explain the TDS value ($P<0.05$). However, when the Cl+Na value was at least 80% of the TDS value (mg/L) (observations included, n=58) there was not a significant difference between the two readings ($p=0.078$) (Figure 8).

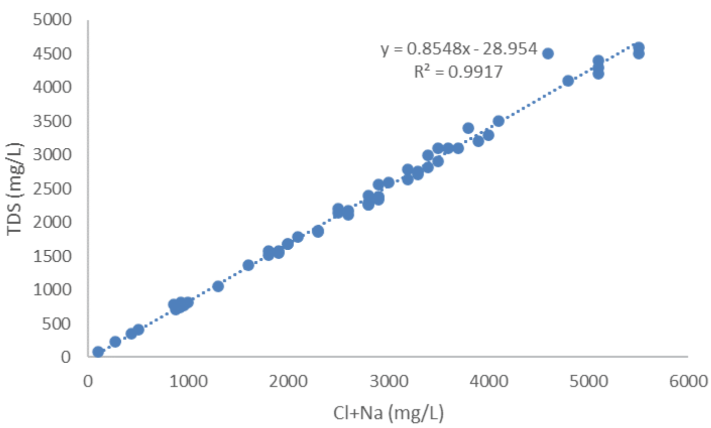

Figure 8: TDS is explained by Cl+Na when the combined content was at least 80% of the TDS value (mg/L).

When NO_2 (nitrite) was included with Cl and Na the combined value (mg/L) had to equate to around 75% of the corresponding TDS value (observations included, n=88) to establish that there was not a significant difference between the two readings ($p=0.086$) (Figure 9).

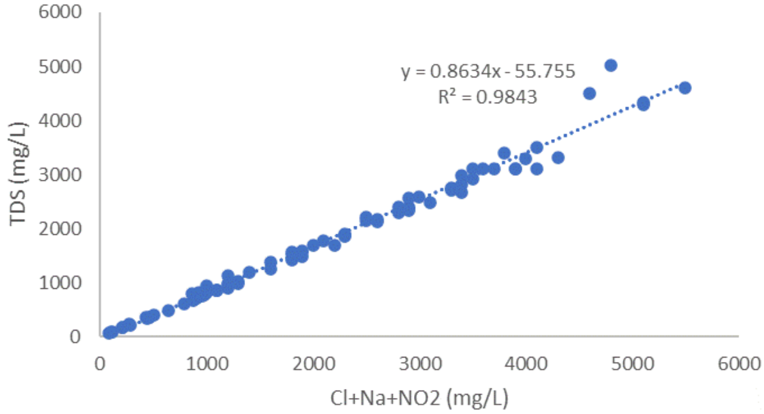

Figure 9: TDS is explained by Cl+Na+NO_2 when the combined content was at least 75% of the TDS value (mg/L).

For the final collection of samples, laboratory analysis established the content of NO_2, Cl, Na, SO_4, $CaCO_3$, Ca, Fe, K, Mg, Mn and Se in each sample. All elements were combined for each sample and compared to the corresponding TDS values (observations included, n=32). It was found that there wasn't a significant difference between combined values and the TDS readings ($p=0.678$) (Figure 10).

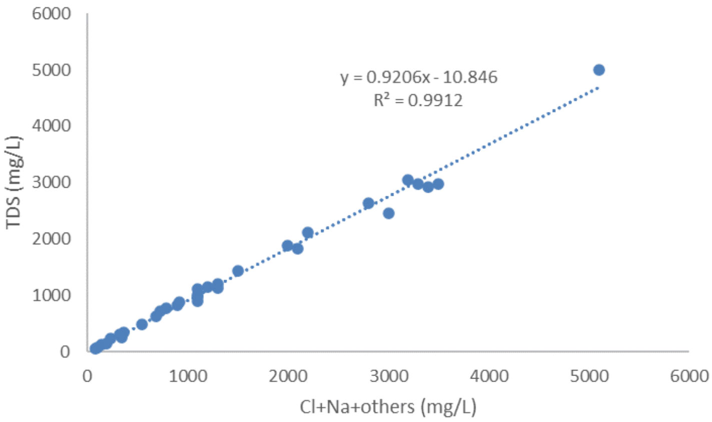

Figure 10: TDS is explained by NO_2, Cl, Na, SO_4, $CaCO_3$, Ca, Fe, K, Mg, Mn and Se.

From the chemical analyses it is possible to conclude that Na and Cl made up more than 50% of almost all samples and around half have at least 75% Na and Cl. However, minor elements can also be important when explaining TDS values at certain production sites.

b) ***Evaluation of portable on-farm water meters***

In comparing the AD11 with the Eutech for pH, a significant difference in pH readings was not found (p=0.646). Data were analysed using an single factor ANOVA. with a positive correlation between the readings (Figure 11).

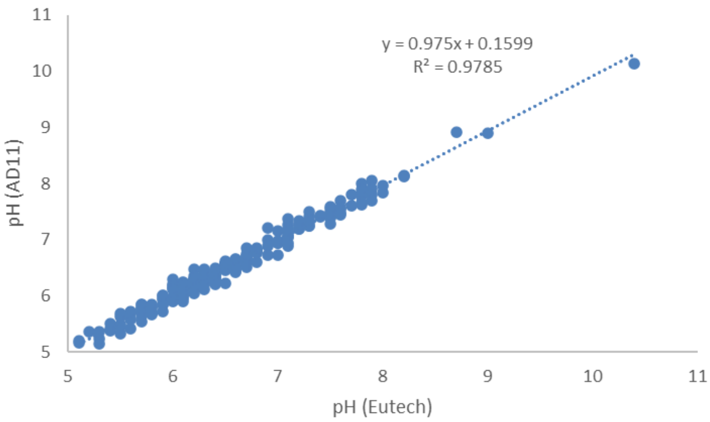

Figure 11: Comparison of pH values obtained from the AD11 and Eutech meters

The laboratory analysed TDS values were not significantly different from those of the Eutech meter (data not shown) for each of the batches collected over the various seasons (P>0.05), and consequently were highly correlated (Table 1). Data were analysed by using an single factor ANOVA and calculating the Pearsons correlation coefficient.

Table 1: Single factor ANOVA P-values and the Pearsons correlation coefficient (R) values for laboratory analysed TDS values and corresponding Eutech values taken during each of the seven collection periods.

	p-value	R value
Summer 22	0.411	0.994
Autumn 22	0.274	0.995
Winter 22	0.389	0.995
Spring 22	0.295	0.993
Summer 23	0.212	0.987
Autumn 23	0.265	0.996
Winter/Autumn 23	0.391	0.990

Figure 12 shows the positive relationship between the laboratory analysed TDS values and those from the Eutech meter found over the course of the project.

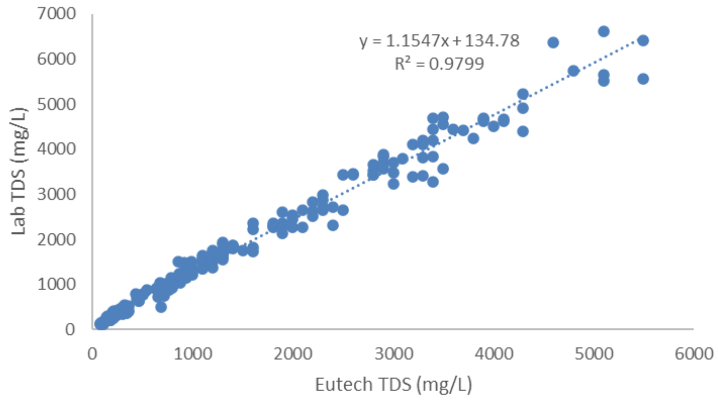

Figure 12: Comparison of laboratory generated TDS values versus those from the Eutech meter.

In comparing the AD32 meter with the Eutech meter, a significant difference for TDS readings was not found ($p=0.915$). A positive correlation between the readings from each meter was found (Figure 13).

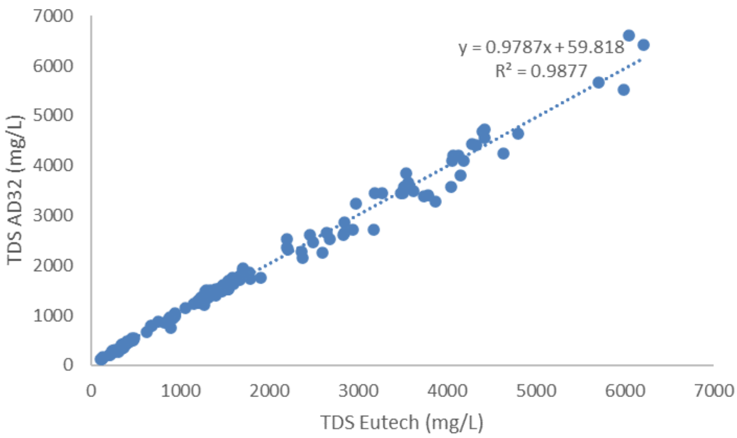

Figure 13: Comparison of the AD32 and Eutech meters for TDS.

In comparing the AD32 meter with the Eutech meter for conductivity a significant difference between the two was not found ($p=0.937$). A positive correlation between the readings from each meter was found (Figure 14).

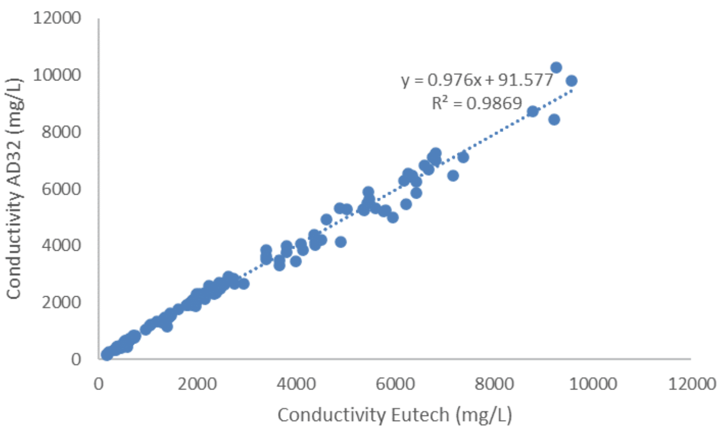

Figure 14: Comparison between the AD32 and Eutech meters for conductivity.

In comparing the laboratory TDS values with those form the AD32 meter a significant difference was not found (p=0.702). A positive correlation between the readings from the laboratory and the AD32 meter was found (Figure 15).

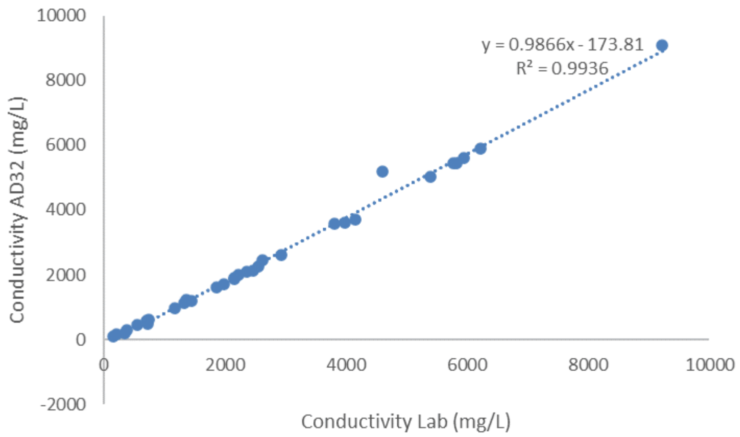

Figure 15: Comparison between the AD32 meter and laboratory for conductivity.

In comparing the laboratory results with the Eutech for conductivity a significant difference was not found (p=0.813). A positive correlation was found between the readings from the laboratory and the Eutech meter (Figure 16).

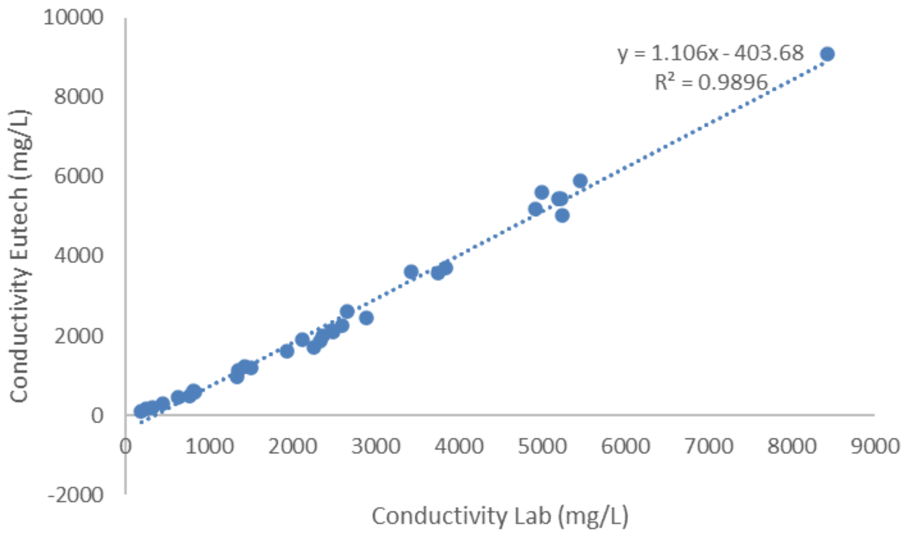

Figure 16: Comparison between the Eutech meter and laboratory for conductivity.

These findings indicated that portable meters available for producers are reliable for measuring pH, TDS and conductivity. It is important that they are correctly calibrated as per the instructions. The Eutech meter is more complicated to calibrate than the AD11 and AD32 meters. In addition, both are cheaper than the Eutech meter.

In the Eutech and AD32 meters, TDS is calculated as a fixed conversion factor from the conductivity measurement, e.g., 0.65. However, it is known that this factor varies in water, hence, this factor would also vary in the samples collected in this project.

c) *Acceptable levels for TDS, Cl and Na*

The TDS value of the water samples ranged from 80 to 5,500 mg/L. Of the total samples, 83% had a TDS level below 3,000 mg/L, 32% had a Cl level below 250 mg/L, and 32% had a Na level below 150 mg/L (Figure 17). Just over 60% of samples had an acceptable TDS level but unacceptable Cl and Na levels. Of the samples, the lowest TDS level, that corresponded to safe Cl and Na levels, was 800 mg/L. For Cl and Na levels to be considered consistently safe, the equivalent TDS values were below 500 mg/L.

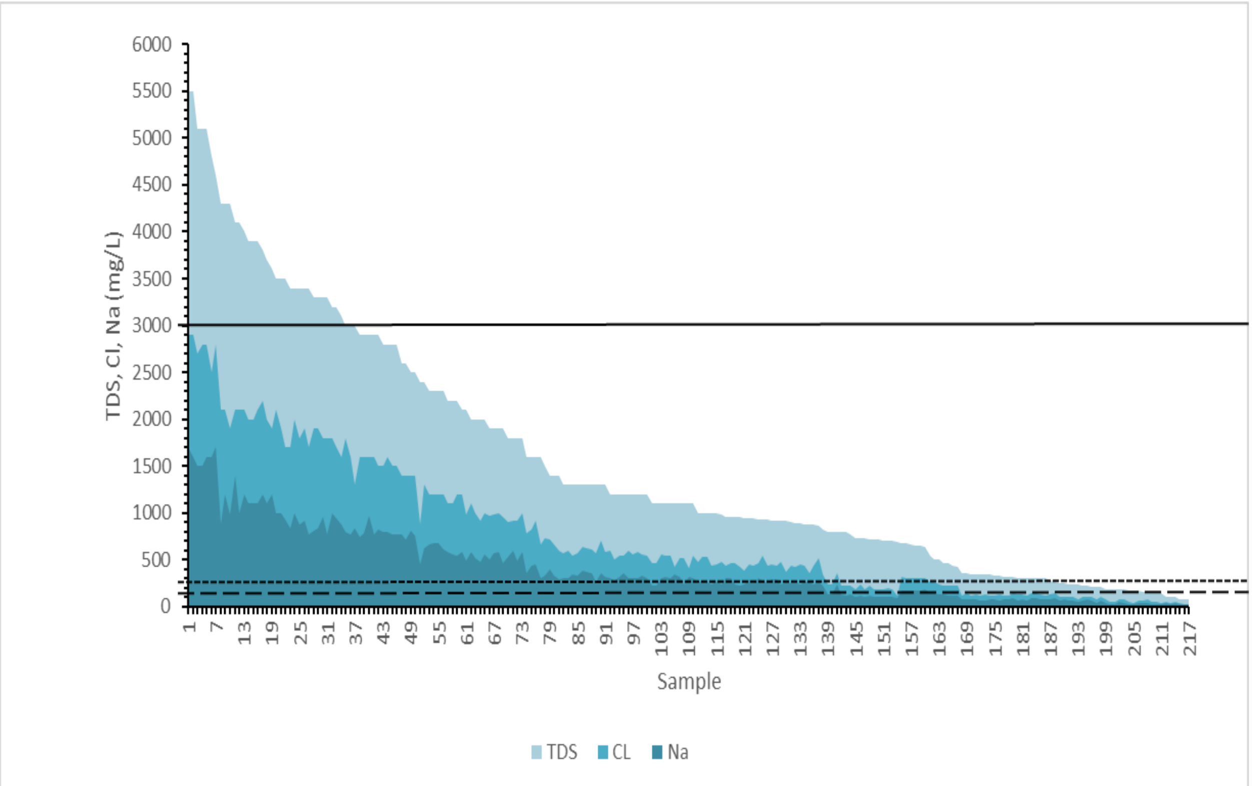

Figure 17. The value (mg/L) for TDS, chloride and sodium, for 217 water samples collected at 3-monthly intervals from 31 sites for source water fed to pigs in Western Australia [acceptable standard where published: TDS, <3 000 mg/L (—); Chloride, <250 mg/L (--); Sodium, <150 mg/L (‒‒)]

Table 2 provides a summary of the percentage of samples in each agricultural area that exceeded the standards, as described in Edwards and Crabb (2021) and Patience (2011), for TDS, Cl, Na, nitrite, sulphate and pH. Of particular interest was the percentage of samples that had a Cl and Na level above the standard.

Table 2: The percentage of samples taken from each of the agricultural areas over the 2 years that exceeded the standard* levels for each of the parameters measured in the water samples.

Agricultural area	Total Dissolved Solids	Chloride	Sodium	Nitrite	pH
North	0%	61%	57%	0%	29%
East	38%	81%	80%	27%	30%
South	9%	73%	73%	32%	32%
Central	0%	40%	40%	0%	3%

*Standard where published (Edwards and Crabb 2021):
Total Dissolved Solids, <3000mg/L; Chloride, <250mg/L; Sodium, <150mg/L; Nitrite, <10µg.N/L; Sulphate, <200 mg/L; pH, 6.0 to 8.0

With regard to the sampling periods, there was a small difference in the percentage of samples that exceeded the standards for each of the parameters analysed in the different periods (Table 3). However, the pattern associated with these differences was as expected with salinity decreasing and nitrite levels increasing over the wetter months.

Table 3: The percentage of samples taken from each of the sampling periods over the 2 years that exceeded the standard* levels for each of the parameters measured in the water samples.

Period	Total Dissolved Solids	Chloride	Sodium	Nitrite	pH
Summer 22	19%	71%	68%	16%	29%
Autumn 22	10%	65%	65%	19%	19%
Winter 22	16%	65%	65%	23%	19%
Spring 22	16%	68%	68%	26%	29%
Summer 23	23%	68%	68%	6%	23%
Autumn 23	10%	68%	68%	19%	19%
Winter/Autumn 23	16%	71%	68%	16%	29%

*Standard where published (Edwards and Crabb 2021):
Total Dissolved Solids, <3000mg/L; Chloride, <250mg/L; <Sodium, 150mg/L; Nitrite, <10µg.N/L; Sulphate, <200 mg/L; pH, 6.0 to 8.0

Sulphate was analysed in water samples collected in autumn 2022 and spring/winter 2023. A small percentage of samples from the east and south presented with a reading exceeding the standard (Table 4). Samples collected in spring/winter 2023 were also analysed for a range of elements. Iron, magnesium and manganese exceeded the standard level for some samples whilst the level for alkalinity, calcium, potassium and selenium found in all water samples did not exceed the standard level (Table 4).

Table 4: The percentage of samples taken from each of the agricultural areas over the two years that exceeded the standard* levels for each of the parameters measured in the water samples.

Agricultural area	Sulphate	Iron	Magnesium	Manganese
North	0%	0%	0%	29%
East	9%	0%	27%	18%
South	6%	25%	0%	13%
Central	0%	60%	0%	0%

*Standard where published (Edwards and Crabb 2021); Patience, J.F. (2011) :
Sulphate, <200mg/L; Iron, <0.3mg/L; Magnesium, <150mg/L; Manganese, <0.05 mg/L

These finding suggest that the generally acceptable level for TDS, being less than 3,000 mg/L, is not a good proxy for the safe level of Cl and Na found in water sources fed to pigs in WA. For the other elements tested, there were some concerns indicating that producers should understand the make up of TDS for their water.

5. Conclusions

The purposes of this Project were to: evaluate water quality parameters; evaluate portable on-farm water meters; and assess acceptable levels for TDS, Cl and Na in water fed to pigs in Western Australia. As the water samples were taken from sources that are used to feed pigs, it is understood that if it was possible, a producer may have changed the composition of this water to benefit the pigs. Hence, comparing samples across time was not reliable but still provided some indication that there was possibly a seasonal influence, and quite likely that water content is different between the various regions. Nevertheless, analyses within samples were reliable with indications that most water samples had more than 50% Cl and Na, but other elements such as iron, magnesium and manganese, may be of concern on some production sites.

This finding is interesting for producers using on-farm water meters that measure TDS because it provides a general indication as to what comprises TDS. In terms of the three meters, the Eutech, AD11 and AD32, tested in this Project, all proved to be reliable.

A key finding in this Project was the disparity between TDS, Cl and Na levels in water and the recommended safe levels for each, for pigs. The majority of samples had a TDS level below the accepted standard level of 3,000 mg/L. However, only a third of samples had an acceptable standard level of Cl and Na. Hence it may be concluded that the generally acceptable level for TDS is not a good proxy for the acceptable level of Cl and Na found in water sources fed to pigs in WA. As producers have ready access to TDS meters but not Cl and Na testing, it is important that they have a good understanding of TDS in terms of the inorganic salts that comprise their TDS measurement. In addition, determining the relationship between Cl and Na in the feed and water offered to pigs could ultimately enhance piggery financial viability. An abstract based on findings from this Project was accepted for presentation at the 2023 Australasian Pig Science Association (Inc) Conference in November 2023, and will further enhance this discussion.

As an extension to this Project, PIWA has been successful in attaining funding from the Federal Government's Extension and Adoption of Drought Resilience Farming Practices Grants Program. The Project, *Managing water in a changing climate - An extension toolkit to facilitate adoption of best practice water management for pork and poultry producers in Western Australia*, will enable factsheets and info notes pertaining to the findings from this Project to be written and extended to producers in Western Australia.

6. Outcomes and recommendations

The following outcomes were achieved from this Project:

a) Water test result summaries sent to project participants after each sampling round;

b) A summary of key points from this Project available for all pork producers in Western Australia;

c) A conference abstract detailing specific findings from this Project to be presented at the 2023 Australasian Pig Science Association (Inc) Conference, November 2023;

d) A sucessful grant application to facilitate extension activites associated with the findings from this Project.

It is recommended that further work be conducted to examine the relationship between Cl and Na levels in water and in feed on case sites where high levels of Na and Cl were recorded. This is because total Na and Cl intake could be impacting production health and economic viability of piggeries in WA.

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8. Appendices

a) Appendix 1

Variation for Project: *A case study: assessing the quality of source water fed to pigs in Western Australia* (P2124 221)

Reason: To date, the data collected for this Project is not showing a significant variation in the seasonal variability of locally sourced water used by a broad representation of WA piggeries for key water quality parameters, including salinity. With the record rainfalls received this winter, it is expected that this pattern would be the same for the planned final two treatments.

An unexpected preliminary finding has been the recommended safe levels for TDS not mirroring the safe levels for Cl and Na (an abstract on this matter has been submitted to APSA). This finding is important because producers have access to meters to measure TDS but cannot measure Cl and Na on-farm.

It is therefore proposed that the final two sampling rounds be reduced to one (September instead of August and October) and remaining operating funds be directed towards testing an expanded suite of parameters, including all soluble ions that make up TDS, as well as laboratory salinity.

As we have had to measure pH in the field throughout this Project (due to time limits associated with laboratory analyses) we have been using a portable on-farm water meter to also measure TDS from the beginning of the Project. Hence, reducing the number of treatments from four to three for the second year will not hinder the original Project objectives. Instead, this variation will provide an opportunity to add important findings relevant for producers, and also for the project PIWA has just been successful in attaining: *Managing water in a changing climate - An extension toolkit to facilitate adoption of best practice water management for pork and poultry producers in Western Australia* as part of the Federal Government's Extension and Adoption of Drought Resilience Farming Practices Grants Program.

No other variations are requested, including no change to funding. Due to savings in pH laboratory testing and reducing the number of treatments from eight to seven, there are adequate funds to now do the additional laboratory analyses and subsequent inquiry requested in this variation.

Proposed changes to Project Agreement P2124 221, executed 13/12/21:

- **Brief Project Description,** under **PROJECT DETAILS** (page 2)

  Add: *Determine if the recommended safe levels for TDS mirror the safe levels for Cl and Na and other relevant soluble ions in water offered to pigs in WA*.

- **Service / Action to be provided / undertaken,** under **SCHEDULE 3 - SERVICES TO BE PROVIDED BY SERVICE PROVIDER DURING PROJECT PERIOD** (page 7) – amend Application Form as follows:

  Add: (to Objective 1) *Samples will be tested on-site using a portable on-farm test meter*.

  Change: Objective 3 Delivery Date to *1st October 2023*.

  Replace: (in RESEARCH PROJECT METHODOLOGY, 1. Selection of study farms, sample collection) *Collection of water samples will be conducted at four times of the year, broadly representing summer, autumn, winter and spring, to examine the impact of season on the assessments of the key water quality parameters. This will be repeated in the following year.*

  with

Collection of water samples will be conducted at four times of the year, broadly representing summer, autumn, winter and spring, to examine the impact of season on the assessments of the key water quality parameters. In the following year, three samples will be collected, broadly representing summer, autumn, winter/spring.

Replace: (in RESEARCH PROJECT METHODOLOGY, 2. Laboratory analyses)
The samples will be tested for key water quality parameters (TDS/salinity, conductivity, pH, nitrites, chloride and sodium) at the Marine and Freshwater Research Laboratory (MAFRL) at Murdoch University. This is a NATA-accredited laboratory (Accreditation Number: 10603) and is also ISO/IEC 17025:2017.

with

The samples will be tested for key water quality parameters (TDS/salinity, conductivity, pH, nitrites, chloride and sodium) for the first six treatments. For the final treatment, testing will be expanded to include all soluble ions that make up TDS. In addition laboratory salinity will be analysed. Laboratory analyses will be done at the Marine and Freshwater Research Laboratory (MAFRL) at Murdoch University. This is a NATA-accredited laboratory (Accreditation Number: 10603) and is also ISO/IEC 17025:2017.

Replace: (in RESEARCH PROJECT METHODOLOGY, 5. Evaluation of portable on-farm water meter)
In Year 2, following one year's worth of data and its interpretation, a portable (waterproof) on-farm water meter capable of determining pH, temperature, TDS, conductivity and salinity will be purchased and its use verified against laboratory analyses of water samples for that year. It is necessary to verify the meter with continued independent laboratory analysis to properly 'field-test' the device.

with

A portable (waterproof) on-farm water meter capable of determining pH, temperature, TDS, conductivity and salinity will be purchased and its use verified against laboratory analyses of water samples for all samples. It is necessary to verify the meter with continued independent laboratory analysis to properly 'field-test' the device.

Replace: (in RESEARCH PROJECT METHODOLOGY, 5. Evaluation of portable on-farm water meter)
Data will be collated and analysed to demonstrate (a) geographical, (b) seasonal and (c) yearly variation in the water quality parameters measured.

with

Data will be collated and analysed to demonstrate (a) geographical, (b) seasonal, (c) yearly variation in the water quality parameters measured and (d) if the recommended safe levels for TDS mirror the safe levels for Cl and Na and other relevant soluble ions in water offered to pigs in WA.

b) Appendix 2

With regard to dissemination of project interim findings, for all sampling rounds, producers received a summary of their specific results derived from the laboratory analyses and pH testing. Figure A1 is an example of results sent after the fourth sampling round (information has been changed as results are confidential for each producer).

A case study: assessing the quality of source water fed to pigs in Western Australia

PIWA Pork Innovation WA

Preliminary results (Confidential)

These results are based on **four** samples with the following selected analyses completed so should only be used as an **indication** as to the quality of your water.

		Sample 1						Sample 2						
	Description	**Date**	**pH**	**TDS**	**Cl**	**NO2**	**Na**	**Date**	**pH**	**TDS**	**Cl**	**NO2**	**Na**	**SO4**
		27/01/2022	5.9	5500	2900	<2	1700	**5/05/2022**	5.96	4600	2800	<2	1700	310
Standard where published			6.0 to 8.0	<3000	<250	<10	<150		6.0 to 8.0	<3000	<250	<10	<150	<200

		Sample 3						Sample 4					
	Description	**Date**	**pH**	**TDS**	**Cl**	**NO2**	**Na**	**Date**	**pH**	**TDS**	**Cl**	**NO2**	**Na**
		9/08/2022	6.3	4800	2500	14	1600	**17/10/2022**	5.81	5100	2700	63	1500
Standard where published			6.0 to 8.0	<3000	<250	<10	<150		6.0 to 8.0	<3000	<250	<10	<150

Where TDS: Total Dissolved Solids (mg/L); **Cl:** Chloride (mg/L); **NO_2:** Nitrite (µg.N/L); **Na:** Sodium (mg/L); **SO_4:** Sulphate (mg/L)

The information contained in this Report is based on independent laboratory tested samples of water only. These independent laboratory test results have been compared to generalised data, where that data is publicly available and is of a general nature only. The data is provided under the PIWA Project, A case study: assessing the quality of source water fed to pigs in Western Australia. The providers shall not be liable for loss, cost, damages or expenses incurred by the client, or any other person or company, resulting from the use of any information or interpretation given in this report and in no case shall the providers be liable for consequential loss including, but not limited to, lost profits. Except as prohibited by law, we disclaim and take no responsibility for any errors in, or omissions from, the information. You should not rely upon this information but should make your own enquiries about the subject matter of this document.

Figure A1: An example of results sent to producers after the fourth sampling round (information has been changed as results are confidential for each producer).

c) *Appendix 3*

An abstract based on findings from this Project was accepted for presentation at the 2023 Australasian Pig Science Association (Inc) Conference.

9. Is total dissolved solids a reliable proxy for chloride and sodium levels in water offered to pigs?

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Introduction The suitability of water for pigs in all production phases depends largely on the soluble salts present in it. Hence, salinity of the water they drink is an important property affecting water consumption. Pluske *et al.* (2006) found that small increases in water use, due to, for example, a high salt level and (or) the price associated with water treatment, decreased overall piggery financial viability. Western Australia (WA) has the largest underground salt, predominately chloride (Cl) and sodium (Na), reserves in Australia (Sexton, 2003), resulting in the corresponding groundwater being saline to some degree. The total dissolved solids (TDS) content is often used as a proxy to represent salinity with the generally recommended safe level in water being less than 3 000 mg/L (Department of Primary Industries and Development, 2021). Edwards and Crabb (2021) found that Cl and Na were among the most common water parameters to exceed the acceptable standard (250 mg/L and 150 mg/L, respectively) in source water fed to pigs. They also noted that excess Cl and Na can cause increased water intake, can affect the gut microbiome, and importantly impact the activity of some antibiotics delivered via the water. However, little has been documented on TDS, Cl and Na levels in water for pigs. The aim of this study was to determine if the recommended safe levels for TDS mirrored the safe levels for Cl and Na in water offered to pigs in WA.

Material and methods Water samples were collected from 31 sites producing pigs in WA. These sites were located throughout the agricultural regions with collections made at 3-month intervals in 2022, giving a total of 124 samples. Samples were tested for TDS, Cl and Na according to standard procedures at the Marine and Freshwater Research Laboratory, Murdoch University (a NATA-accredited laboratory, Accreditation Number: 10603; ISO/IEC 17025:2017). Values for TDS, Cl and Na were arrayed for each sample.

Results The TDS value of the water samples ranged from 80 to 5 500 mg/L. Of the total samples, 84% had a TDS level below 3 000 mg/L, 33% had a Cl level below 250 mg/L, and 33% had a Na level below 150 mg/L (Figure 1). Just over 50% of samples had an acceptable TDS level but unacceptable Cl and Na levels. Of the samples, the lowest TDS level, that corresponded to safe Cl and Na levels, was 800 mg/L. For Cl and Na levels to be considered consistently safe, the equivalent TDS values were below 500 mg/L.

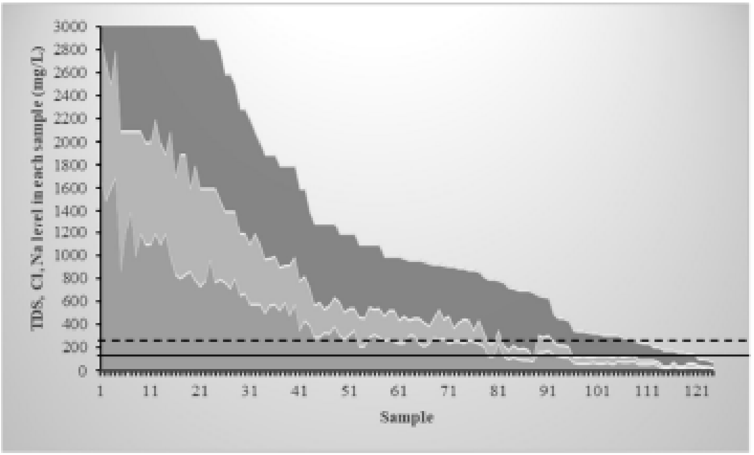

Figure 1. The value (mg/L) for TDS (■), chloride (■) and sodium (■), for 124 water samples collected at 3-monthly intervals from 31 sites for source water fed to pigs in Western Australia [acceptable standard where published: TDS, <3 000 mg/L; Chloride, <250 mg/L (- - -); Sodium, <150 mg/L (—)].

Conclusion and implications These data show the disparity between TDS, Cl and Na levels in water and the recommended safe levels for each, for pigs. Based on these findings, it can be concluded that the generally acceptable level for TDS, being less than 3 000 mg/L, is not a good proxy for the safe level of Cl and Na found in water sources fed to pigs in WA. It could be deduced that a TDS level of 500 mg/L is almost certainly safe and possibly as high as 800 mg/L could be acceptable. As producers have ready access to TDS meters but not Cl and Na testing, further research is required to better understand TDS in terms of the inorganic salts that comprise the TDS measurement in Western Australian water as well as seasonal and regional influences. In addition, determining the relationship between Cl and Na in the feed and water offered to pigs could complement this research and ultimately enhance piggery financial viability.

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