



**Prize Winner**

# **Scientific Inquiry**

## **Year 7-8**

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# Scientific Inquiry on the Quality of Drinking Water in South Australian Public Playgrounds

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## **ABSTRACT**

This scientific inquiry investigates the quality of drinking water in several South Australian (SA) public playgrounds. This investigation uses potential of Hydrogen (pH) and Total Dissolved Solids (TDS) to measure the quality of the water. Two digital meters were used to measure the pH and TDS levels. After testing 40 different playgrounds around SA, the recorded results were analysed. The results showed high pH levels (more alkaline water) in the northern region of SA. Most of these playgrounds in this region had pH levels outside the safe drinking pH range. TDS levels were higher in the southern region of SA. The best quality water was found to be in the playgrounds in Adelaide and nearby suburbs.

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# 1. Introduction

Water is the main part of our body. Drinking good quality water is therefore very important for our health. Children and their families spend a lot of time at playgrounds and it is important to have good quality drinking water at these locations. This scientific inquiry investigates the quality of water available at many different SA playgrounds. The two measures used to estimate the quality of water are the pH and TDS. The pH level would indicate the acidity/alkalinity of the water. The TDS level would indicate the amount of solids possibly toxic substances in the water. The two measurements (pH and TDS) were made at each of the selected 40 different playgrounds across SA. These playgrounds were selected within a radius of 200km from the Adelaide city.

The main water supplier in SA is the SA Water Company. The SA Water publishes regular reports presenting levels of impurities such as Ammonia, Lead etc. [1] in their supplied water. However these reports are not as detailed as ours as our focus is pH and TDS levels in different playgrounds all around SA. The SA Water reports give data only for large regions of Adelaide and do not present TDS information or specific data about the quality of drinking water at SA playgrounds. SA Water results are generated from selected supply points. However, the quality of the drinking water from these supply points can change as water travels through the metal pipes. Rusted pipes can add harmful impurities to the water. So it is important to measure the water quality at the receiving point at the playgrounds.

The structure of this report is as follows:

Chapter 2 describes pH and TDS, their safe levels and effects on our health. Chapter 3 lists the selected playgrounds in SA. Chapter 4 describes the testing equipment and method used to estimate pH and TDS levels. Chapter 5 presents the recorded pH and TDS measurements and analysis. Chapter 6 gives the conclusion presenting a summary of important observations. Finally, references and acknowledgements are given in Chapter 7 and Chapter 8.

## 2. Two Important Measures of Water Quality

The two measures used to estimate the quality of drinking water (pH and TDS) are discussed in this chapter.

### 2.1 pH

pH is one of the important measurements used to determine the quality of drinking water. pH measures the acidity or the alkalinity of the water. The pH levels range from 0 to 14. 0 is considered the most acidic, 7 is neutral and 14 the most alkaline. The higher the pH number is, the more alkaline it is and the lower the number the more acidic. Figure 1 below shows pH levels of common drinks [2].

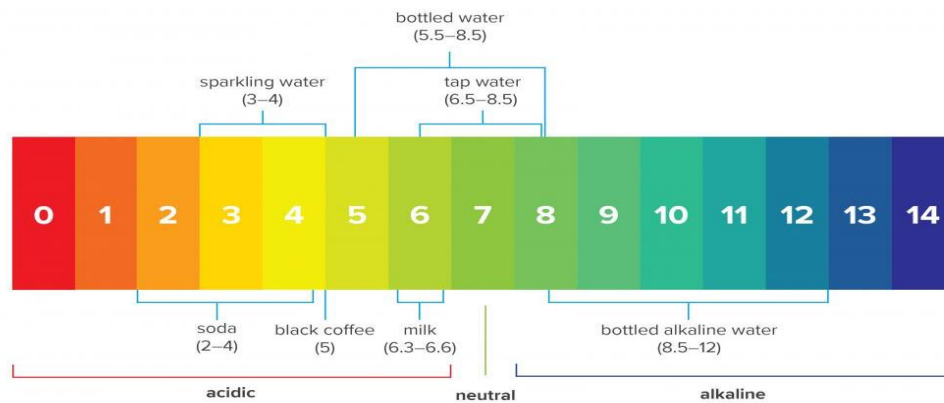


Figure 1: pH levels of common drinks

### 2.1.1 Impact on our health and safe pH range

According to a water utility company in Victoria (Australia) called South East Water, the most suitable and safe pH level in drinking water should be around 6.5 to 8.5. This pH range is also recommended by the United States Environmental Protection Agency (US EPA) [3] and advises people that water outside this range may not be safe to drink.

Water with really low pH or a really high pH level is a sign of heavy metal pollution and bacterial life in the water. Acidic water can dissolve the metal of our water pipes and is dangerous for us as acidic water can contain harmful minerals such as iron, copper and lead and if consumed can lead to cancer, high blood pressure, kidney and brain damage. Children have higher risk of having these diseases as their bodies are at a growing stage and easily can absorb dangerous toxins from the water. Slightly alkaline water is commonly consumed and considered safe, however high alkaline water can cause many side effects such as headaches, vomiting, hand tremors etc. High alkaline water has a high mineral content that creates aesthetic problems such as making the water taste bitter and smell unpleasant. The pH level can change due to pollution and this can also harm animals and plants that live in that water.

There are many claims that drinking high alkaline water can help to reduce ageing, prevent cancer, help with weight loss and give other health benefits [4]. However, according to the Mayo Clinic, regular water is best for most people. They state that there is no scientific evidence that fully verifies the claims made by supporters of alkaline water [5].

## 2.2 Total Dissolved Solids (TDS)

TDS stands for Total Dissolved Solids. TDS consists of many metals, minerals and salts. TDS is found in water as a result of both human and natural caused activities, e.g. irrigation, farming and mining. If the water has a really high amount of TDS, it can change the water's colour, scent and taste making it a totally different type of liquid compared to water with a

low TDS level. TDS can enter water from different places like storm water, mineral springs, urban runoff, industrial waste water, sewage etc. and then are poured into machines for purification. However purification will not remove all the toxic solids in the water. TDS is measured in milligrams per litre (mg/L), also equal to parts per million (ppm).

### 2.2.1 Impact on our health

High TDS levels can create a disliked taste that makes the water taste really salty, bitter and even metallic. If the water has a high TDS level there is high chance there are toxic and dangerous minerals present in the drinking water, such as iron, arsenic, nitrate, sulphate and lead which are all harmful for health. Lead is a chemical element that is found on the periodic table. Its exposure can cause serious consequences in both adults and growing children. If people come in contact with high amounts of lead it can harm both the individual's brain and central nervous system. According to a report from 'The Berkey', a service that sells water filters states that an Australian study showed an increased number of deaths with high TDS levels [6]. A World Health Organisation (WHO) report discusses a link between TDS levels and heart disease and cancer [7].

WHO published a set of water ratings using different TDS levels in [7]. These water ratings are shown below in Table 1. A similar rating presented in [8] states that water less than 150 is unacceptable to drink because of too little minerals present in it. However we will be using the WHO ratings to analyse the quality of water at playgrounds. The TDS levels of different types of water (SA Health [9]) are shown in Table 2.

<b>TDS levels (mg/L)(ppm)</b>	<b>Rating</b>
150 - 300	Excellent
300 - 600	Good
600 – 900	Fair
900 - 1200	Poor
Above 1200	Unacceptable (because of too much impurities and minerals)

Table 1: WHO water quality ratings

Rainwater	<100 ppm
Tap	150-400 ppm
Bore water	100 ppm

Table 2: SA health TDS water levels for different water types

### 3. Testing Locations

We tested 40 different playgrounds around SA within 200km from the Adelaide City. We started testing water from 20<sup>th</sup> June to 13<sup>th</sup> July 2020. Water was tested onsite at the playground. Some of the photos taken are shown in Figure 2. The tested playgrounds are listed in Table 3 and marked on the SA map in Figure 3.



Figure 2: pH and TDS levels were measured at the playground (i) Flinders View Park, Port Pirie (ii) Clonlea Skate Park, Gawler (iii) Play and Fun Rotary Park, Christies Beach (iv) Sturt Reserve Children's Playground, Murray Bridge.



#	PLAYGROUND	SUBURB/TOWN	DATE TESTED
01	Semaphore Beach Playground	Semaphore	20/06/2020
02	G.E Hunter Reserve Playground	Port Adelaide	20/06/2020
03	Apex Park West Beach	West Beach	20/06/2020
04	Glenelg Foreshore Play Space	Glenelg	20/06/2020
05	Ashley Street Playground	Torrensville	20/06/2020
06	Carnavon Reserve Playground	Carnavon	20/06/2020
07	Waikerie Community Garden	Waikerie	21/06/2020
08	Barmera Play Space	Barmera	21/06/2020
09	Monash Adventure Park	Monash	21/06/2020
10	The Bert Dix Memorial Park	Renmark	21/06/2020
11	Steamroller Park Playground	Stirling	27/06/2020
12	Sturt Reserve Children's Playground	Murray Bridge	27/06/2020
13	Carisbrook Park	Salisbury Park	29/06/2020
14	Soldiers Memorial Garden Playground	Prospect	02/07/2020
15	Snowtown Centenary Playground Park	Snowtown	05/07/2020
16	Adelaide Square Playground	Crystal Brook	05/07/2020
17	Bowman Park	Crystal Brook	05/07/2020
18	Flinders View Park	Port Pirie	05/07/2020
19	Wallaroo Adventure Park	Wallaroo	05/07/2020
20	Clonlea Skate Park	Gawler	07/07/2020
21	Sixth Avenue Reserve	Ascot Park	10/07/2020
22	Alison Avenue Reserve	Marion	10/07/2020
23	South Bank Boulevard Reserve	Sheidow Park	10/07/2020
24	Play and Fun Rotary Park	Christies Beach	10/07/2020
25	CT Fishers Playground	Victor Harbour	10/07/2020
26	Warland Reserve	Victor Harbour	10/07/2020
27	Kent Reserve	Victor Harbour	10/07/2020
28	Lakala Reserve	Port Elliot	10/07/2020
29	Starfish Park	Harborough	10/07/2020
30	Railway Terrace Playground	Goolwa	10/07/2020
31	Richard Ballard Park	Goolwa	10/07/2020
32	Yankalilla Skate Park	Yankalilla	10/07/2020
33	Yankalilla Playground	Yankalilla	10/07/2020
34	Gumeracha Playground	Gumeracha	11/07/2020
35	Rhynie Playground	Rhyne	12/07/2020
36	Auburn Park and Playground	Auburn	12/07/2020
37	Sanders Park	Clare	12/07/2020
38	Davidson Reserve	Kapunda	12/07/2020
39	Civic Park	Modbury	13/07/2020
40	Ridge Park	Myrtle Bank	13/07/2020

Table 3: Tested playgrounds in SA



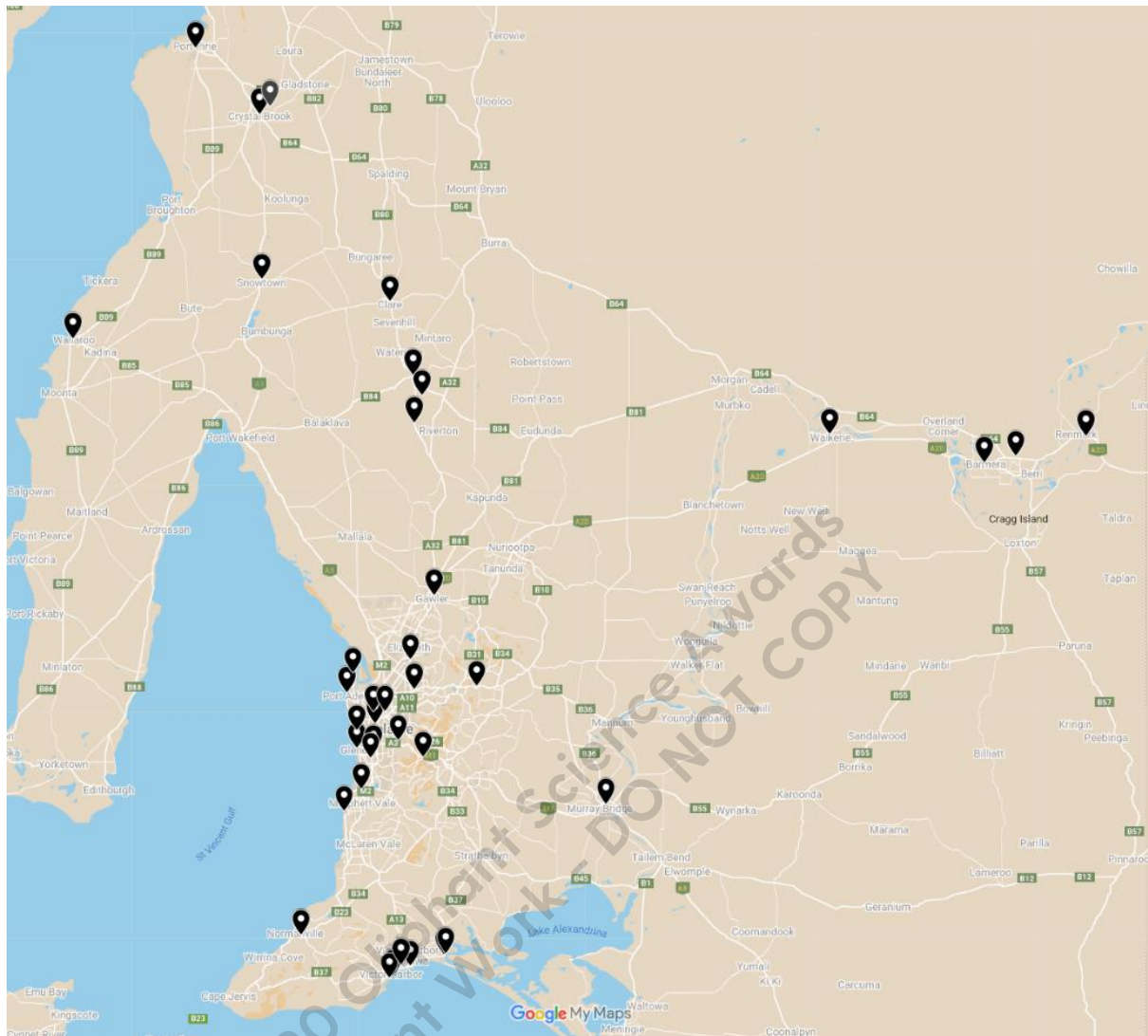


Figure 3: Locations of the tested playgrounds

## 4. Testing Equipment and Method

Two digital meters to measure pH and TDS levels were bought from eBay for AU\$15. Figure 4 shows the type of meters bought. The specifications of the meters given on the instruction booklet are shown in Table 4. This instruction manual states that both of these two meters are professional meters and give results with very good accuracy. The pH meter was first calibrated using the two solutions (pH 6.86 and pH 9.18) provided with the meter. It was calibrated by pressing the calibrating button on the meter and then putting it in the calibration solution for at least 30 seconds. The calibration procedure was repeated for both 6.86 and 9.18 pH solutions.

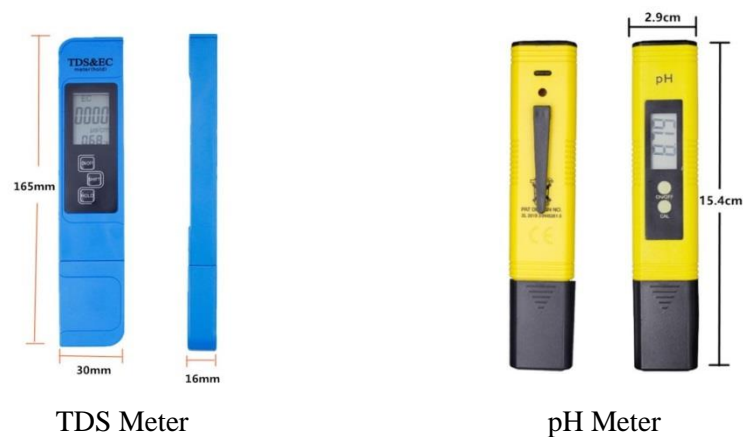


Figure 4: pH and TDS meters

TDS Meter		pH Meter	
TDS Range	0-9999 ppm	Measure Range	0.00-14.00 pH
Operating Temperature	0.1-80.0C	Resolution	0.01pH
Accuracy	±2%	Accuracy	+/-0.01pH
		Operating Temperature	0C—60C

Table 4: Specifications of TDS and pH meters

After the calibration both the pH and TDS meters were tested on a distilled water bottle bought from BigW shown below in Figure 5. The results from this test are shown in Table 5.



Figure 5: BigW distilled water bottle with label

	BigW Distilled Water Specification	Level shown on the meter
TDS	< 1ppm	4 ppm
pH	6	6.1

Table 5: Test results of the meters

The results show the measured levels are very close to the values on the distilled water bottle. This test was carried out regularly before the pH and TDS levels were measured on the water collected at the playground. This was done to make sure the meters were working properly.

## 5. Recorded Measurements and Analysis

The testing locations were all grouped into three different regions which are the Northern Region, Greater Adelaide and Western Towns and finally the Southern Region. The results found are shown in Table 6 below.

ID	PLAYGROUND	SUBURB/TOWN	TDS	pH	DATE TESTED
Northern Region					
01	Adelaide Square Playground	Crystal Brook	141	9.39	05/07/2020
02	Auburn Park and Playground	Auburn	146	9.54	12/07/2020
03	Barmera Play Space	Barmera	124	7.57	21/06/2020
04	Bowman Park	Crystal Brook	145	9.36	05/07/2020
05	Davidson Reserve	Kapunda	146	9.62	12/07/2020
06	Flinders View Park	Port Pirie	136	9.38	05/07/2020
07	Monash Adventure Park	Monash	114	8.16	20/06/2020
08	Rhynie Playground	Rhynie	142	7.87	12/07/2020
09	Sanders Park	Clare	143	9.25	12/07/2020
10	Snowtown Centenary Playground Park	Snowtown	156	9.18	05/07/2020
11	The Bert Dix Memorial Park	Renmark	106	9.49	20/06/2020
12	Waikerie Community Garden	Waikerie	142	7.86	21/06/2020
13	Wallaroo Adventure Park	Wallaroo	154	9.73	05/07/2020
Greater Adelaide Region and Western Towns					
14	Alison Avenue Reserve	Marion	186	7.56	10/07/2020
15	Apex Park West Beach	West Beach	94	7.87	20/06/2020
16	Ashley Street Playground	Torrensville	130	7.92	20/06/2020
17	Carisbrook Park	Salisbury Park	148	7.55	29/06/2020
18	Carnavon Reserve Playground	Carnavon	109	7.64	20/06/2020
19	Civic Park	Modbury	128	7.82	13/07/2020
20	Clonlea Skate Park	Gawler	249	7.55	07/07/2020
21	G.E Hunter Reserve Playground	Port Adelaide	81	7.75	20/06/2020
22	Glenelg Foreshore Play Space	Glenelg	139	8.67	20/06/2020
23	Gumeracha Playground	Gumeracha	152	7.78	11/07/2020
24	Play and Fun Rotary Park	Christies Beach	186	7.49	10/07/2020
25	Ridge Park	Myrtle Bank	163	7.54	13/07/2020
26	Semaphore Beach Playground	Semaphore	168	7.76	20/06/2020
27	Sixth Avenue Reserve	Ascot Park	185	7.61	10/07/2020
28	Soldiers memorial Garden Playground	Prospect	193	7.60	02/07/2020
29	South Bank Boulevard Reserve	Sheidow Park	185	7.40	10/07/2020
30	Steamroller Park Playground	Stirling	154	9.03	20/06/2020
31	Sturt Reserve Children's Playground	Murray Bridge	165	7.54	27/06/2020
Southern Region					
32	CT Fishers Playground	Victor Harbour	274	7.51	10/07/2020
33	Kent Reserve	Victor Harbour	308	7.55	10/07/2020
34	Lakala Reserve	Port Elliot	263	7.52	10/07/2020
35	Railway Terrace Playground	Goolwa	290	7.46	10/07/2020
36	Richard Ballard Park	Goolwa	271	7.51	10/07/2020
37	Starfish Park	Harbourough	304	7.35	10/07/2020
38	Warland Reserve	Victor Harbour	276	7.71	10/07/2020
39	Yankalilla Playground	Yankalilla	268	7.84	10/07/2020
40	Yankalilla Skate Park	Yankalilla	266	7.81	10/07/2020

Table 6: Measured pH and TDS levels of the playgrounds

## 5.1 Analysis of pH measurements

A colour key (shown in Table 7) was created for the pH levels and this was used to colour the playground locations on the map. This makes it easier to compare different pH levels from each other. Green colour was used if the pH level of the playground is in the safe range (6.5 – 8.5) and red if it is outside the safe range. Figure 6 is the pH map that was created using the colour key and the measured pH levels. No playgrounds showed pH level less than 6.5. The coloured map in Figure 6 show that the pH level is higher in the north, indicating high alkalinity in the northern region. It was very surprising to note that the filtered drinking water fountain installed at the widely used play area, the Glenelg Foreshore Play Space had a pH level slightly outside the safe drinking pH range.

pH	Colour Code
Between 6.5 and 8.5 (safe level)	Green
Above 8.5 (outside safe level)	Red

Table 7: pH colour key

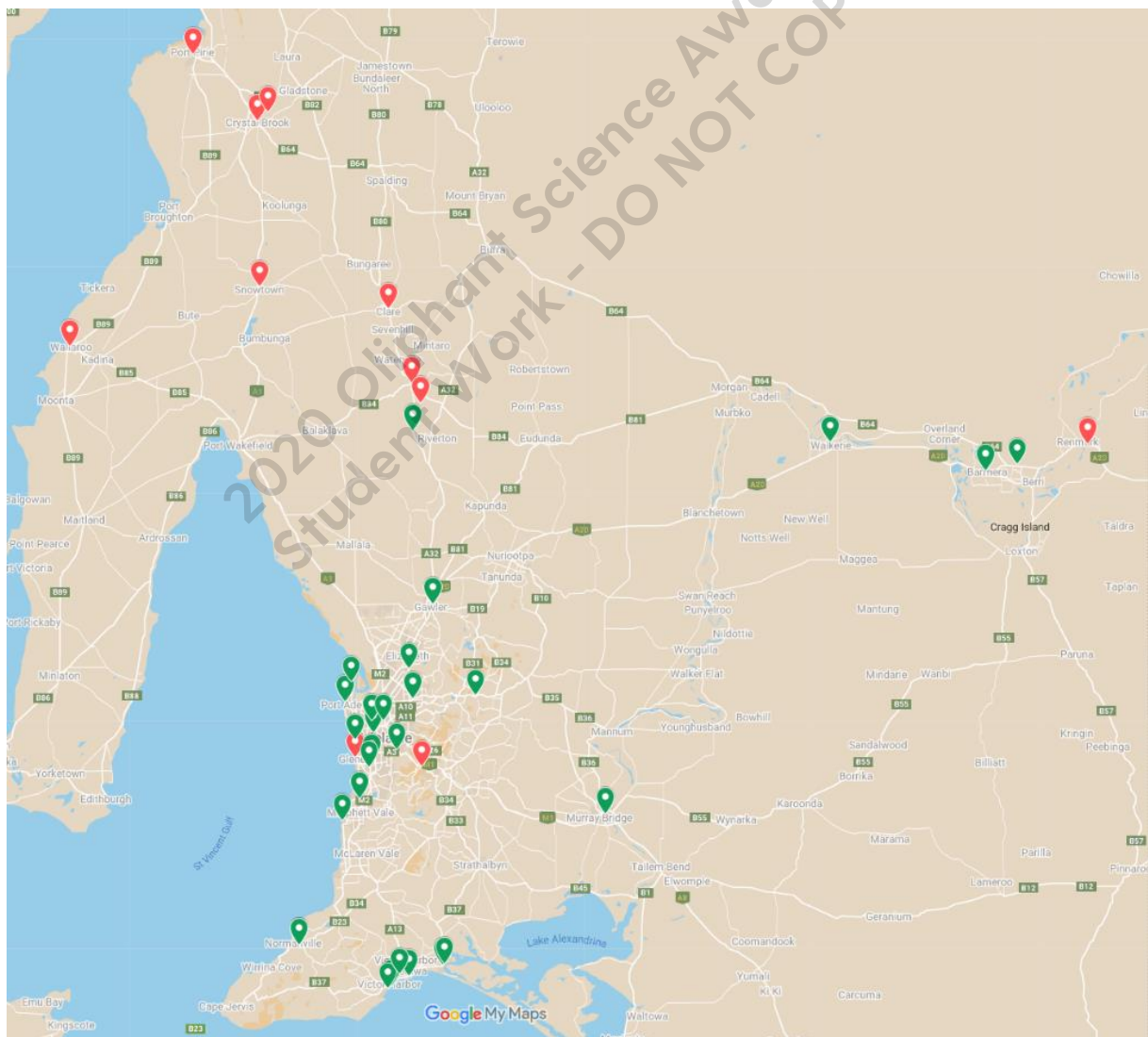


Figure 6: Measured pH levels

The percentage number of playgrounds in each region within the safe pH range and outside this range are given in Table 8. These results are also presented in Figure 7 and 8. The charts in Figure 7 and 8 were created using Microsoft Excel.

Regions	Safe range (6.5-8.5)	Outside safe range (>8.5)
Whole SA	29 (72.5%)	11(27.5%)
North Region	4(30.8%)	9(69.2%)
Adelaide + West	16(88.9%)	2(11.1%)
South Region	9(100.0%)	0(0.0%)

Table 8: Percentage number of playgrounds within safe pH range

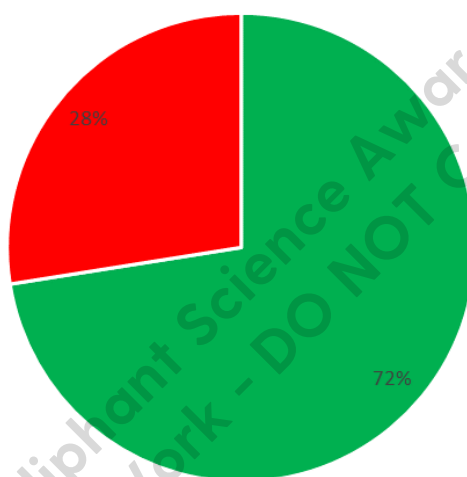


Figure 7: Percentage number of playgrounds within safe pH range (Whole SA)

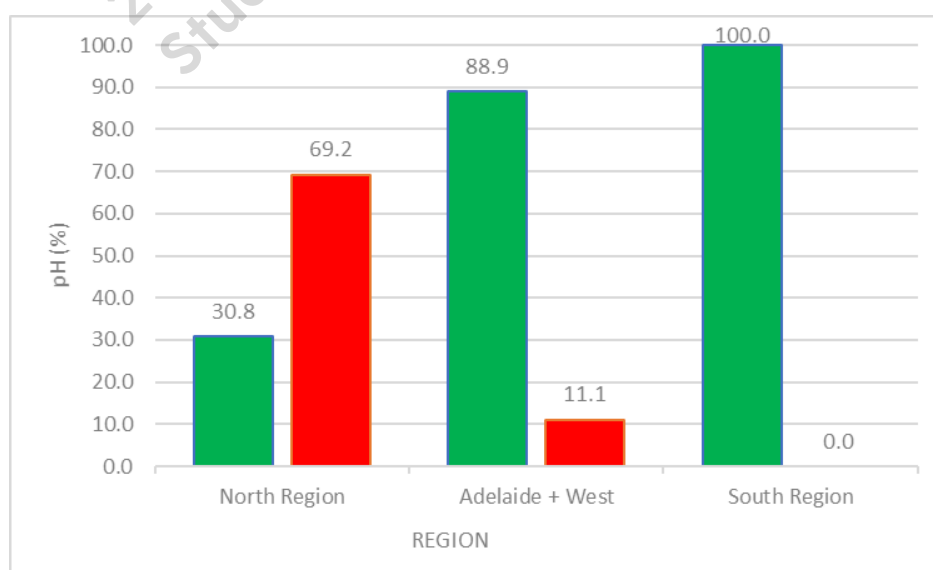


Figure 8: Percentage number of playgrounds within safe pH range

The results in Table 8, Figure 7 and Figure 8 show the pH level is most high in the northern region of SA. About 69% of the playgrounds tested in the northern region had a pH level outside the safe range. The water in the northern region show high alkalinity. The pH level was best in the southern region. About 28% of the playgrounds in the whole SA had pH levels outside the safe pH range.

Figure 9 gives the average pH value for each region of SA. This figure was generated using Microsoft Excel. This figure shows that the whole SA has an average pH level of 8.12. The northern region has an average pH level of 8.95. Compared to this, the southern region has an average pH level of 7.58.

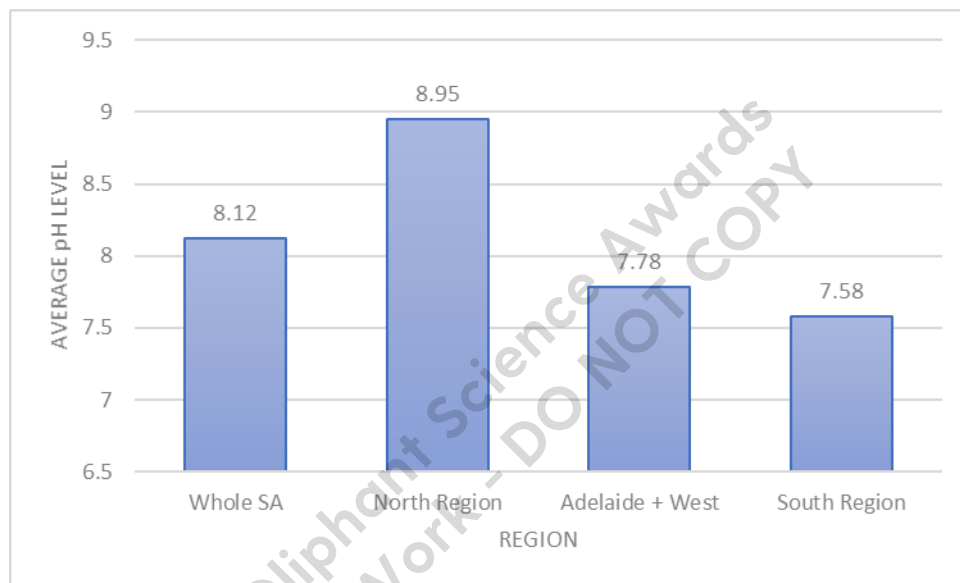


Figure 9: Average pH levels in different regions

## 5.2 Analysis of TDS measurements

Similar to the pH analysis, we created a colour key (shown in Table 9) to colour the map and compare the TDS results. The coloured map using the key is shown in Figure 11. After having a quick glimpse of the map, we observed higher TDS levels in the southern region of SA. The results in Table 6 show two playgrounds in the Adelaide region (Port Adelaide and West Beach) had TDS levels below 100. The TDS classes given in Table 2 indicate the water supplied at these two playgrounds are most likely be rain water. About half of the playgrounds (marked in yellow in Figure 10), mostly on the northern side had TDS levels less than 150 indicating little minerals in the water. The [8] states water with TDS level less than 150 is unacceptable for drinking due to too little amount of minerals in it. However, the rating given by World Health Organisation (WHO) in [7] states water with TDS less than 300 is 'excellent'. Therefore we will use WHO ratings in the analysis.



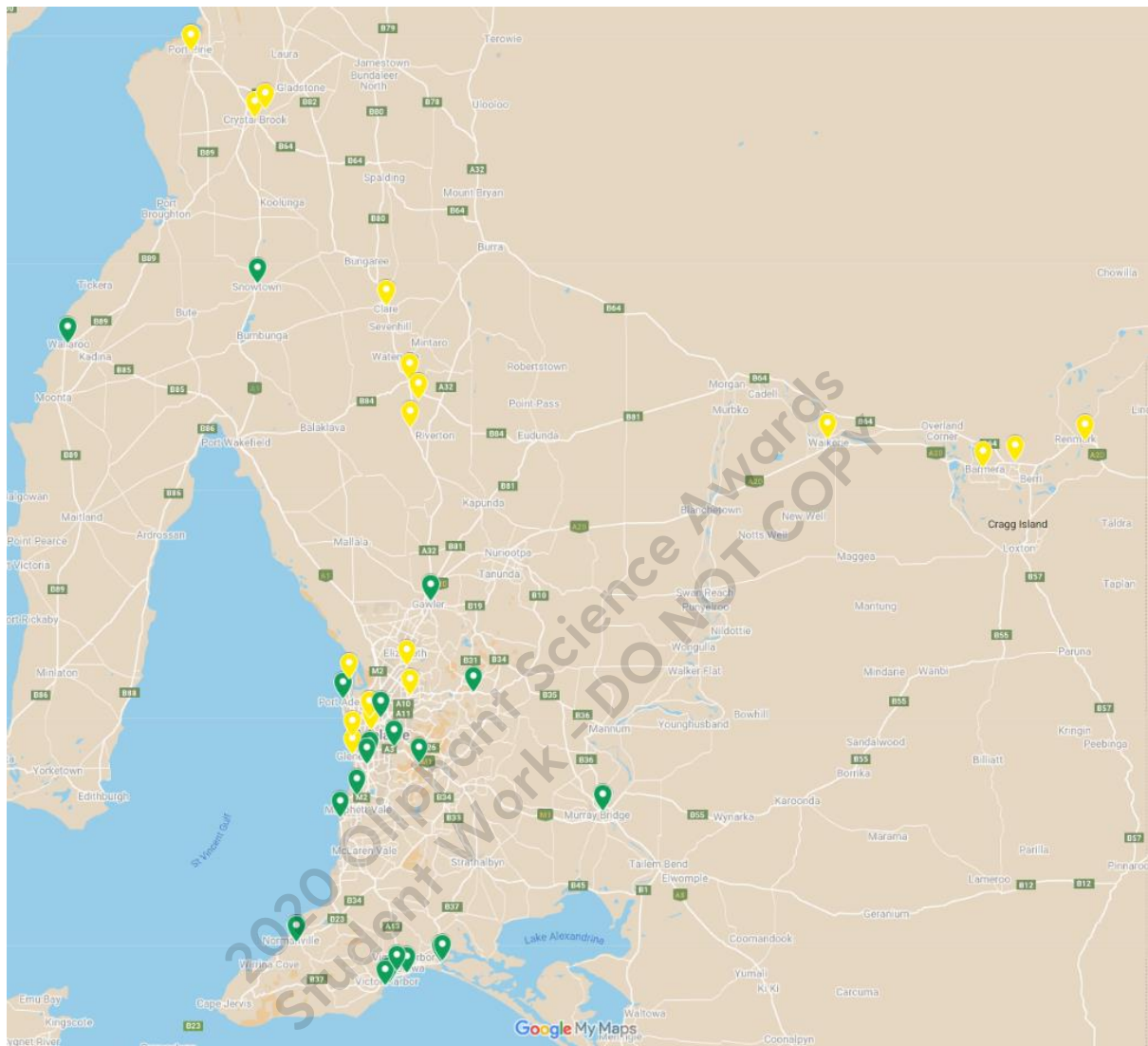


Figure 10: Playgrounds with TDS level less than 150 (marked in yellow). The water in these playgrounds may not be acceptable to drink due to too little mineral content, according to [8].



TDS	Colour Code
Less than 250 ppm	Green
Between 250 and 300 ppm	Orange
Above 300 ppm	Red

Table 9: TDS colour key

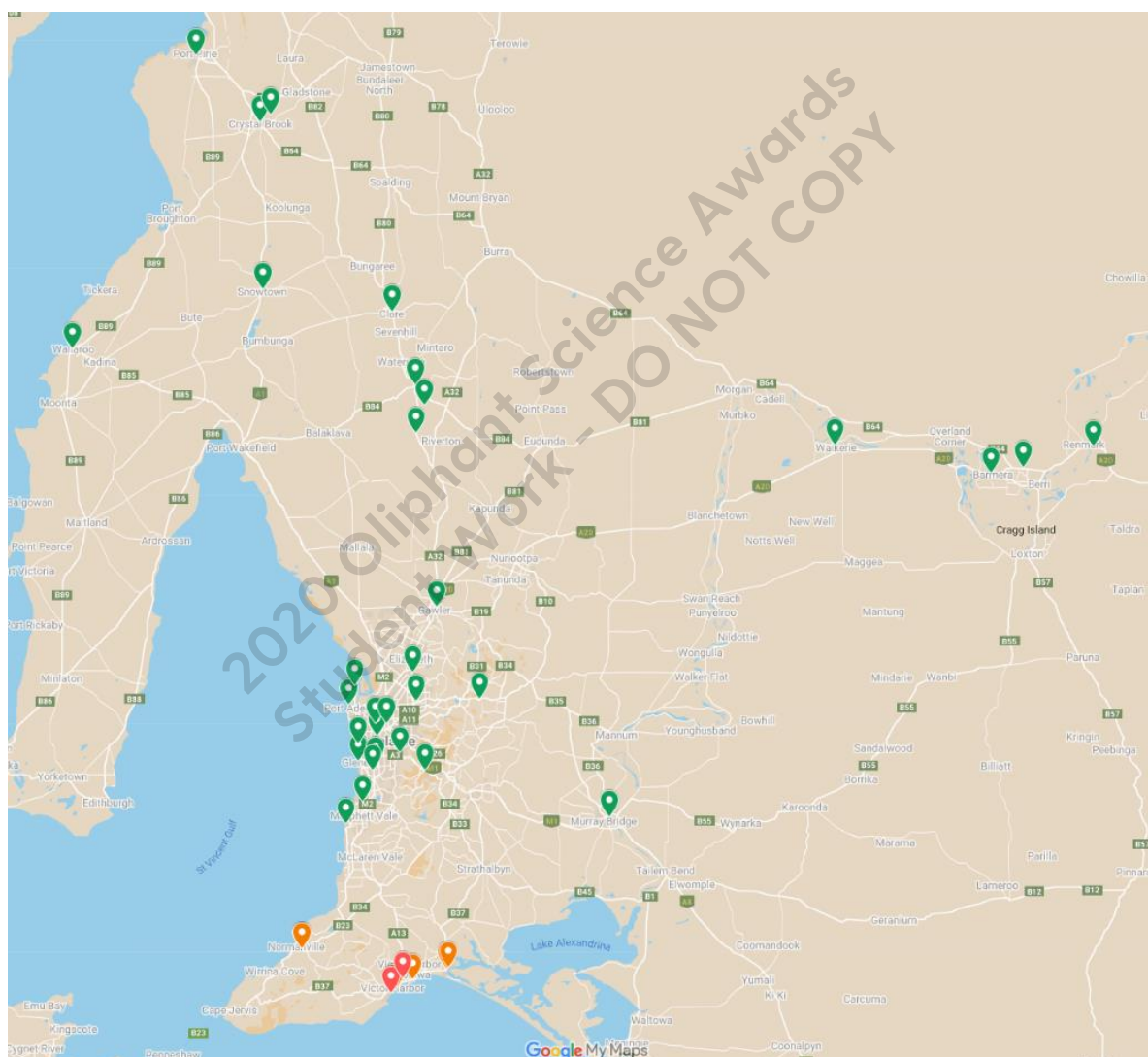


Figure 11: Measured TDS levels

The percentage of playgrounds within the three ranges of TDS (Table 9) are calculated and presented in Table 10. These percentage values are also represented in Figures 12 and 13.

Regions	Less than 250	Between 250 and 300	Between 300 and 350
Whole SA	31(77.5%)	7(17.5%)	2(5.0%)
North Region	13(100.0%)	0(0.0%)	0(0.0%)
Adelaide + West	18(100.0%)	0(0.0%)	0(0.0%)
South Region	0(0.0%)	7(77.8%)	2(22.2%)

Table 10: Percentage number of playgrounds within different TDS ranges

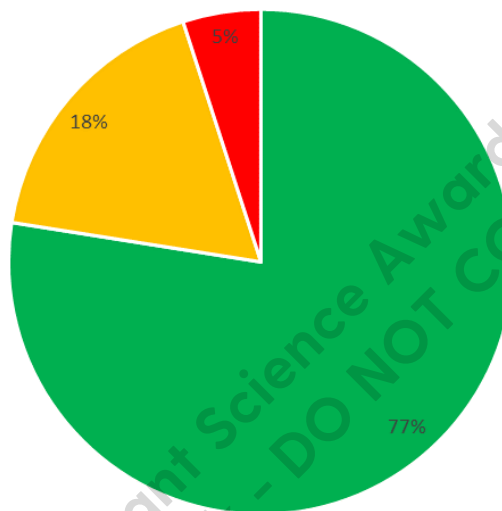


Figure 12: Percentage number of playgrounds within different TDS ranges (Whole SA)

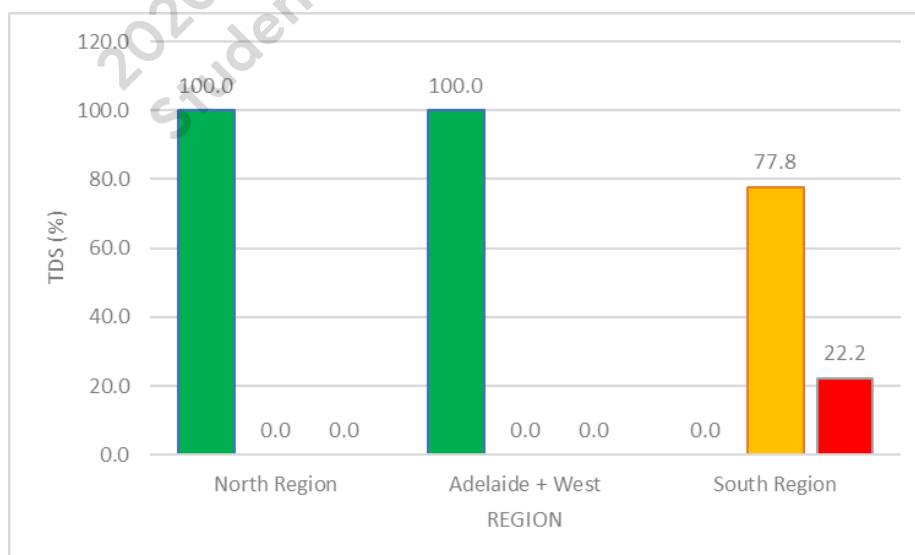


Figure 13: Percentage number of playgrounds within different TDS ranges

The results presented in Table 10, Figure 12 and Figure 13 show 5% of playgrounds in SA were outside the TDS excellent water rating (WHO). TDS levels were most high in the southern region. About 22% of the playgrounds in southern region had TDS level more than 300 which does not meet the excellent rating.

Figure 14 shows the average TDS levels. The average TDS level in whole SA is 178. The highest average was in southern region with a TDS average of 280. Compared to this northern region had an average TDS level of 138.

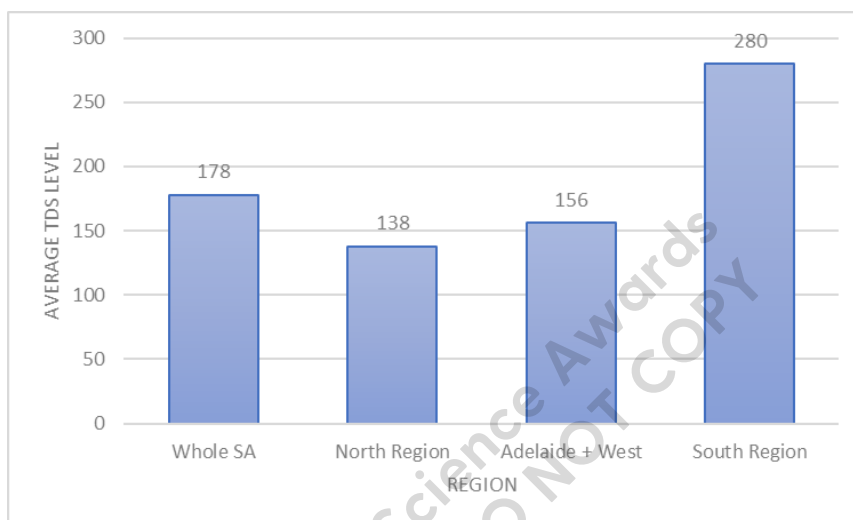


Figure 14: Average TDS levels

The value of all pH values were plotted against TDS values to see whether there is any relationship between the pH and TDS values. The plot is shown in Figure 15. This plot is generated using Microsoft Excel. Figure 15 shows TDS level was about 150 when pH level is greater than 8. A large change in TDS values (from about 80 to about 300) was observed when pH level was less than 8.

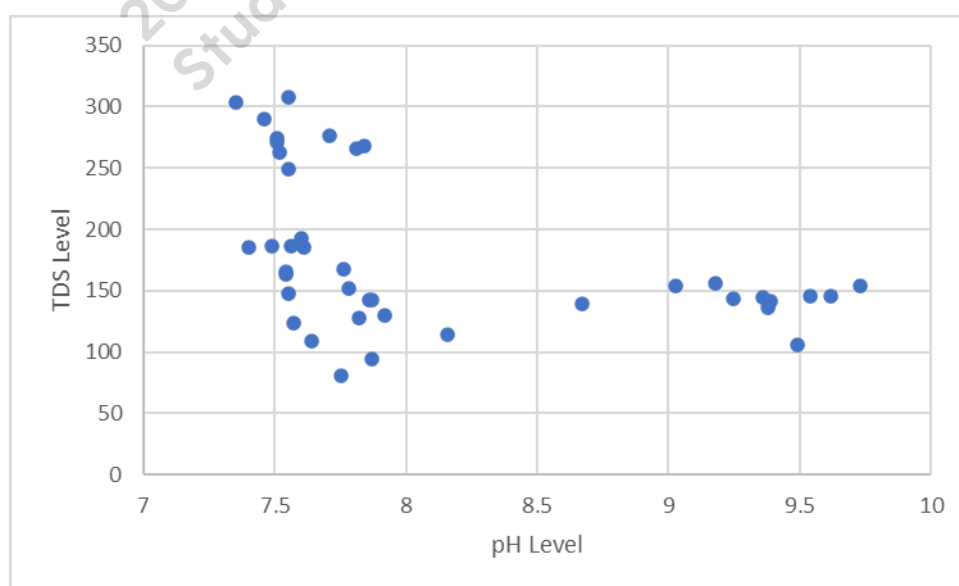


Figure 15: pH and TDS comparison

## 6. Conclusions

This scientific inquiry investigated quality of drinking water in different SA public playgrounds. We tested 40 different playgrounds around SA within 200km from the Adelaide City. The recorded results were analysed using Microsoft Excel and presented in the form of Maps, Tables and Charts. The SA Water Company publishes water quality results at their test supply points and do not provide water quality measurements for the SA playgrounds. This inquiry generated a set of new water quality results that are very useful for children and their family members who spend a lot of time at the SA playgrounds. This report presents for the first time both pH and TDS levels for 40 playgrounds across South Australia.

Some of the important observations made from this inquiry are shown below:

- pH levels are most high in the northern region of SA.
- About 69% of the playgrounds in the northern region had pH level outside the safe range recommended by US EPA [4].
- About 28% of the playgrounds tested in whole SA had pH levels outside safe pH range [4].
- The filtered water supplied at the widely used play space in Glenelg (Glenelg Foreshore Play Space) had a pH level outside the safe pH range.
- Average pH level across whole SA is 8.12 (slightly alkaline). Water with slight alkalinity can be good for our teeth according to my dentist.
- The best quality of water was available in Adelaide and near suburbs.
- TDS levels were higher in the southern region of SA.
- About half of the playgrounds tested (majority in the northern SA) had TDS levels less than 150. According to ratings in [8], water below 150 (TDS) are unacceptable to drink due to too little minerals in it.
- Average TDS level across whole SA was 178. This is within the range given for 'excellent' drinking water given in both [7] and [8].
- A comparison between pH and TDS levels showed TDS was around 150 when pH value is above 8. When pH is less than 8, large values of TDS were observed.

More investigation is required to understand why pH is higher in the northern region and TDS is higher in the southern region. Also it is important to find why the TDS level was around 150 when pH level was larger than 8.

## 7. References

- [1] SA Water Quality Reports:  
<https://www.sawater.com.au/water-and-the-environment/safe-and-clean-drinking-water/your-tap-waters-quality-and-testing/your-drinking-water-profile>
- [2] Medical News Today Website:  
<https://www.medicalnewstoday.com/articles/327185#ph-of-drinks>
- [3] US EPA Website:  
<https://www.epa.gov/sdwa/drinking-water-regulations-and-contaminants>
- [4] Healthline Website:  
<https://www.healthline.com/health/food-nutrition/alkaline-water-benefits-risks#benefits>
- [5] Mayo Clinic Website:  
<https://www.mayoclinic.org/healthy-lifestyle/nutrition-and-healthy-eating/expert-answers/alkaline-water/faq-20058029>
- [6] The Berkey Website:  
<https://theberkey.com/blogs/water-filter/what-is-the-acceptable-total-dissolved-solids-tds-level-in-drinking-water>
- [7] World Health Organisation (WHO) pdf:  
[https://www.who.int/water\\_sanitation\\_health/dwq/chemicals/tds.pdf](https://www.who.int/water_sanitation_health/dwq/chemicals/tds.pdf)
- [8] Find My Health Website: <https://www.findmyhealth.com/en/how-healthy-is-your-drinking-water/8oMRLrNK>
- [9] SA Health Website:  
<https://www.sahealth.sa.gov.au/wps/wcm/connect/public+content/sa+health+internet/public+health/water+quality/salinity+and+drinking+water/salinity+and+drinking+water#:~:text=%E2%80%9Cbased%20on%20taste%2C%20TDS%20in,to%202000%20mg%2FL%20range.>

## 8. Acknowledgments

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