Volcanic Media in Nature Based Treatment System

arris
water treatment
& technology

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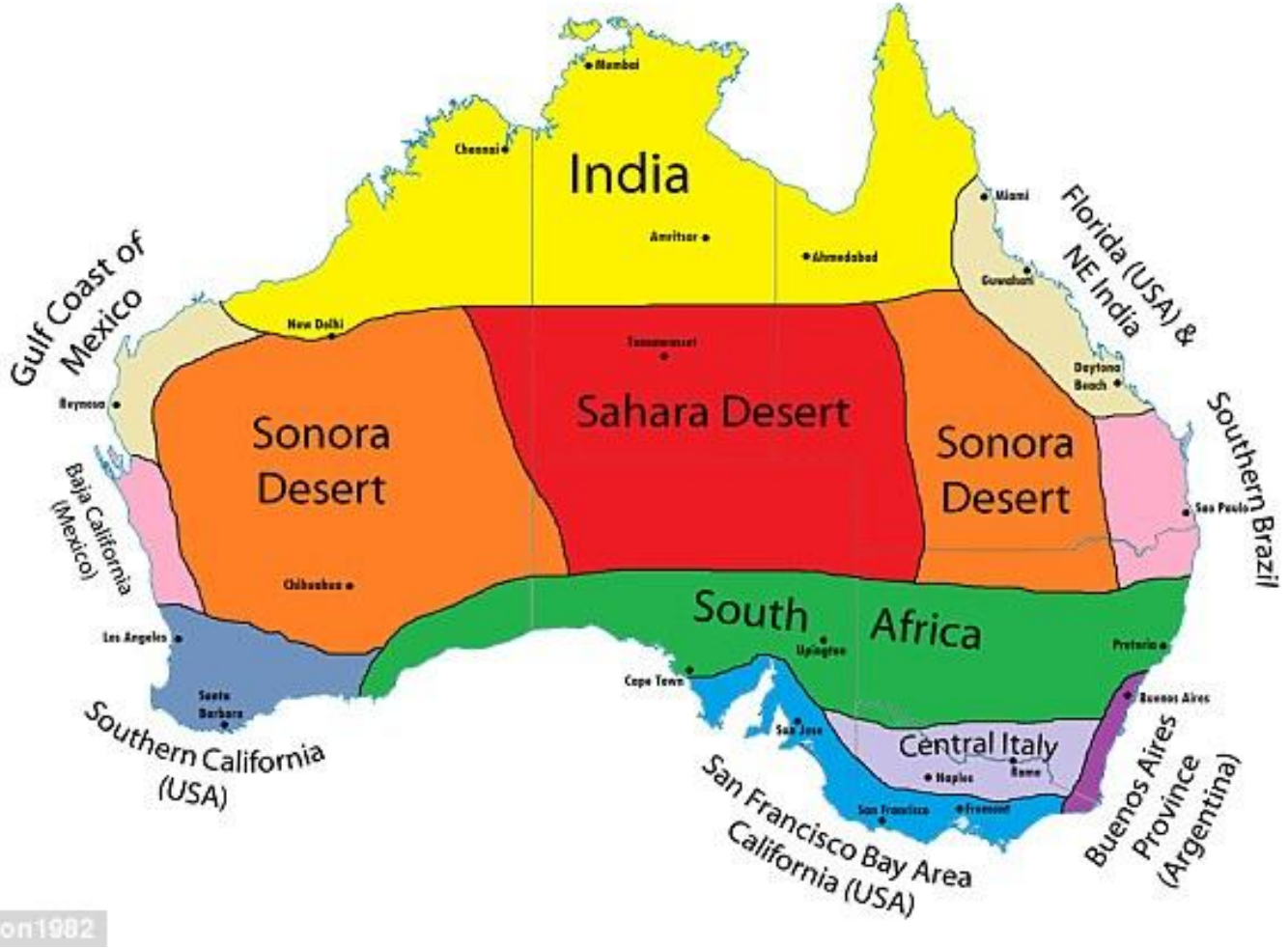
Australia/North America Comparison

Climate Map of Australia



Nature Based Treatment Systems

- Mimic natural systems
  - Constructed wetlands
  - Sand filters
  - Evapotranspiration beds
  - ~~Wisconsin~~ Minnesota Mounds
  - Woodchip filters
  - Soil based treatment systems

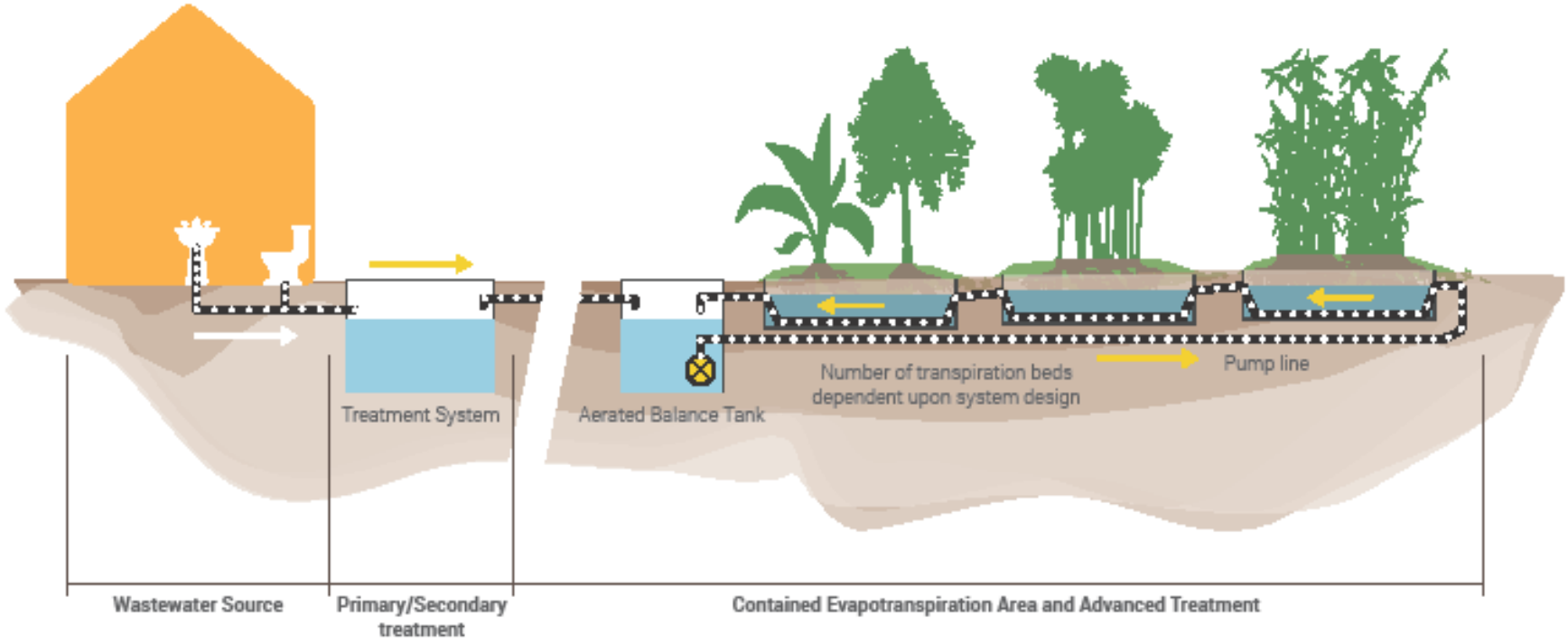
Passive and Low Input Wastewater Systems

- A passive wastewater system is a non-mechanical method of treatment
  - It typically needs no electricity to operate
- A low input wastewater system has minimal mechanical processes
  - Frequently it just involves the pumps required to move water through the treatment system
- Both passive and low impact systems typically mimic natural processes
- Treatment systems, such as constructed wetlands, can be either passive or low input
  - It depends on the site

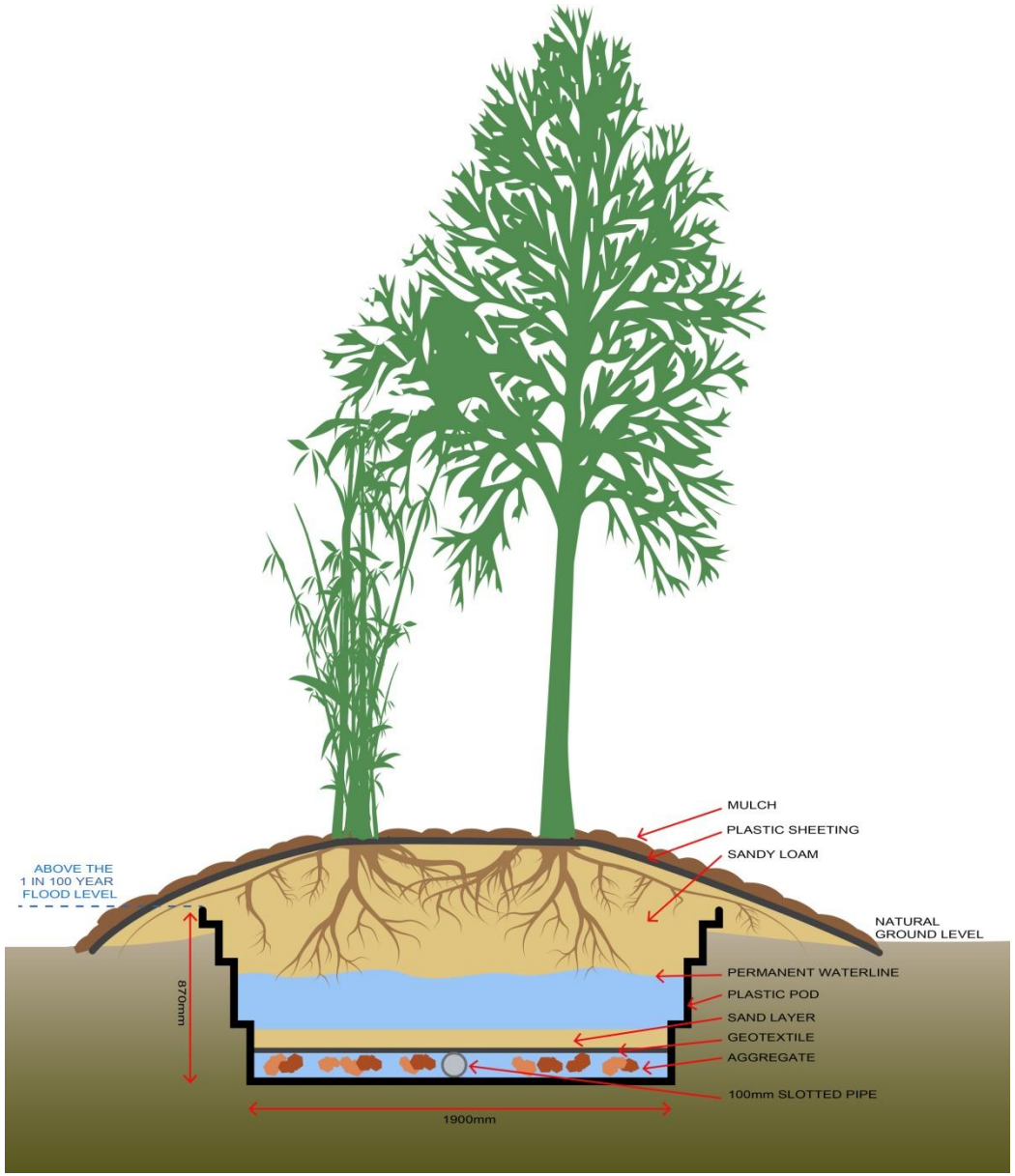
Rhizopod System

- Contained Evapotranspiration Trench
- Marketed as the Rhizopod System
- Developed in Australia
- 1st installation in 1998
  - Tropical Australia
  - 1st Installation in Temperate Australia 2002
- Has a pre-treatment system
- Majority are configured as ‘no-release’
  - Can also be designed to produce a polished recycled water

The Rhizopod System



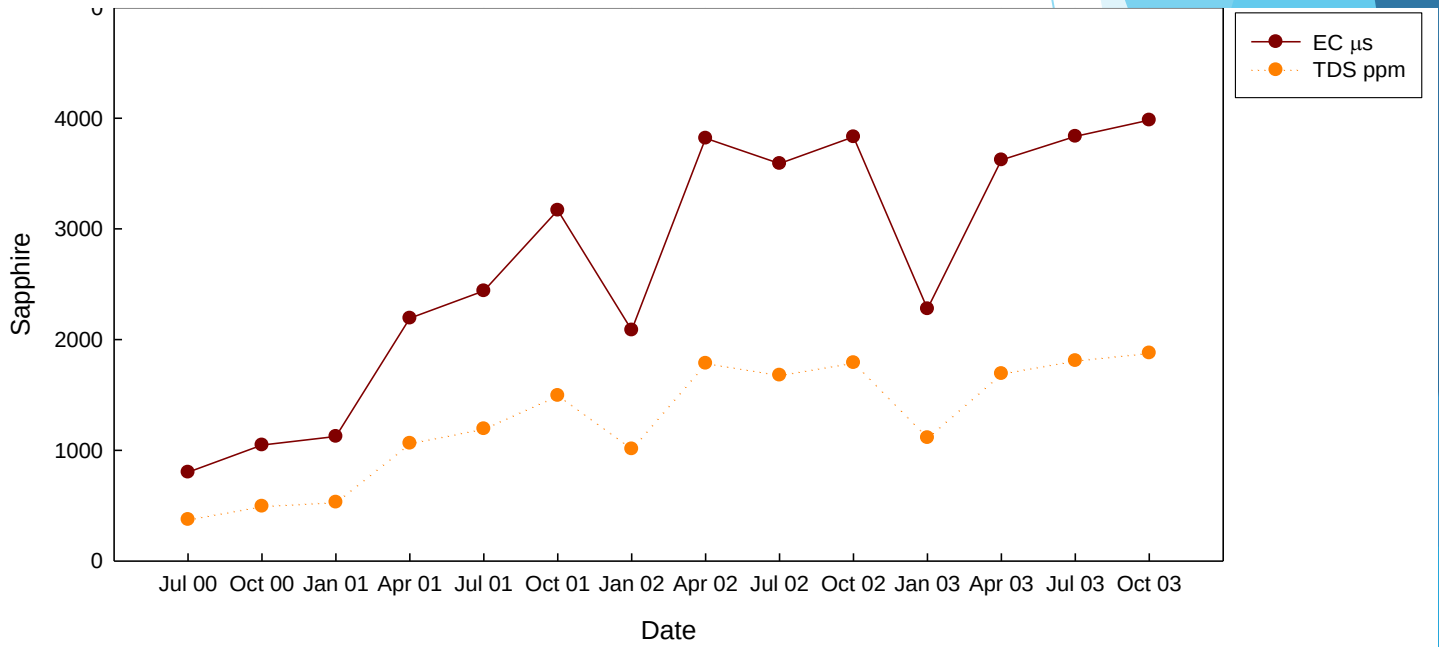
Rhizopod


MULCH
PLASTIC SHEETING
SANDY LOAM
ABOVE THE
1 IN 100 YEAR
FLOOD LEVEL
NATURAL
GROUND LEVEL
PERMANENT WATERLINE
PLASTIC POD
SAND LAYER
GEOTEXTILE
AGGREGATE
100mm SLOTTED PIPE
870mm
1900mm

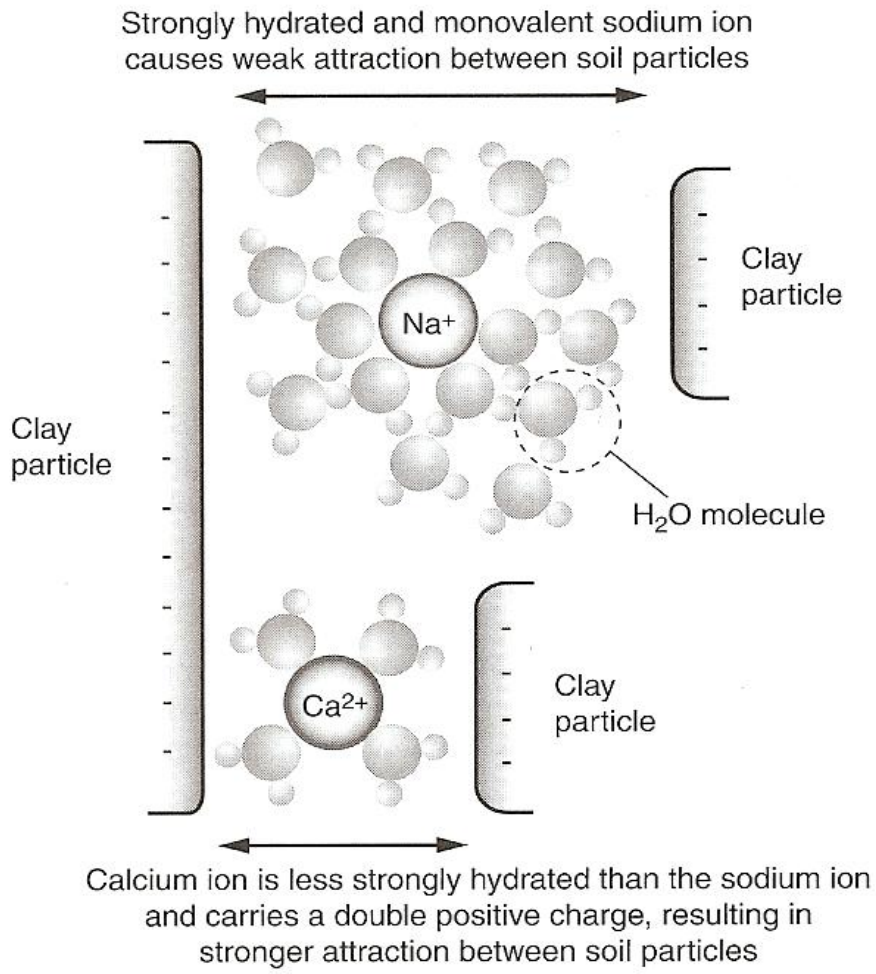
The Rhizopod System

No Such Magic Place as ‘Away’

- In a no-release system some contaminants of concern will accumulate
  - Notably salinity
  - Sodium salts
  - Sodium Adsorption Ratio (SAR)
  - Some heavy metals
  - Variation in nitrogen & phosphorus
- Management is required



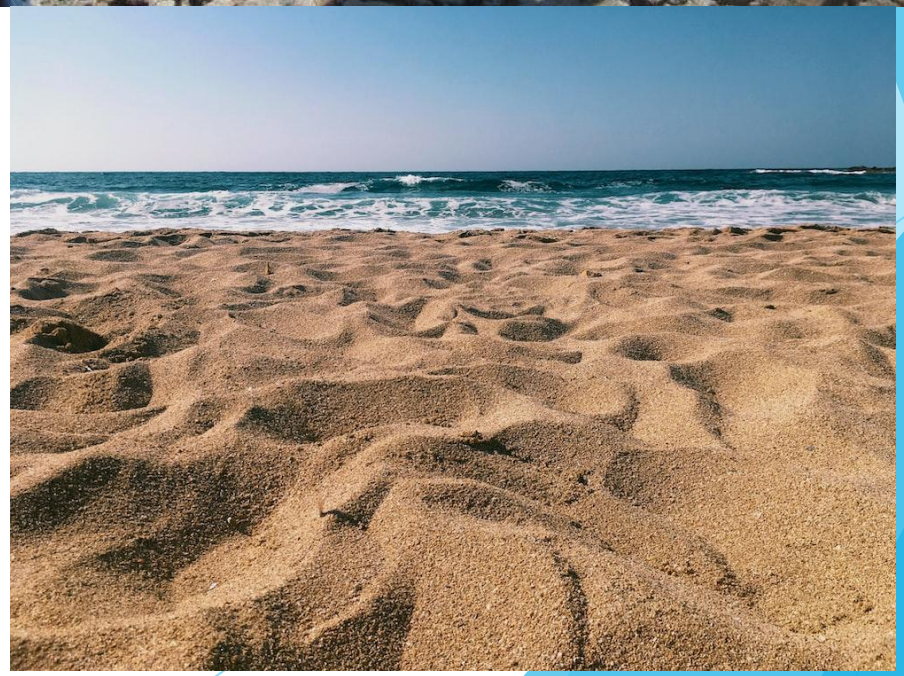
Sodicity



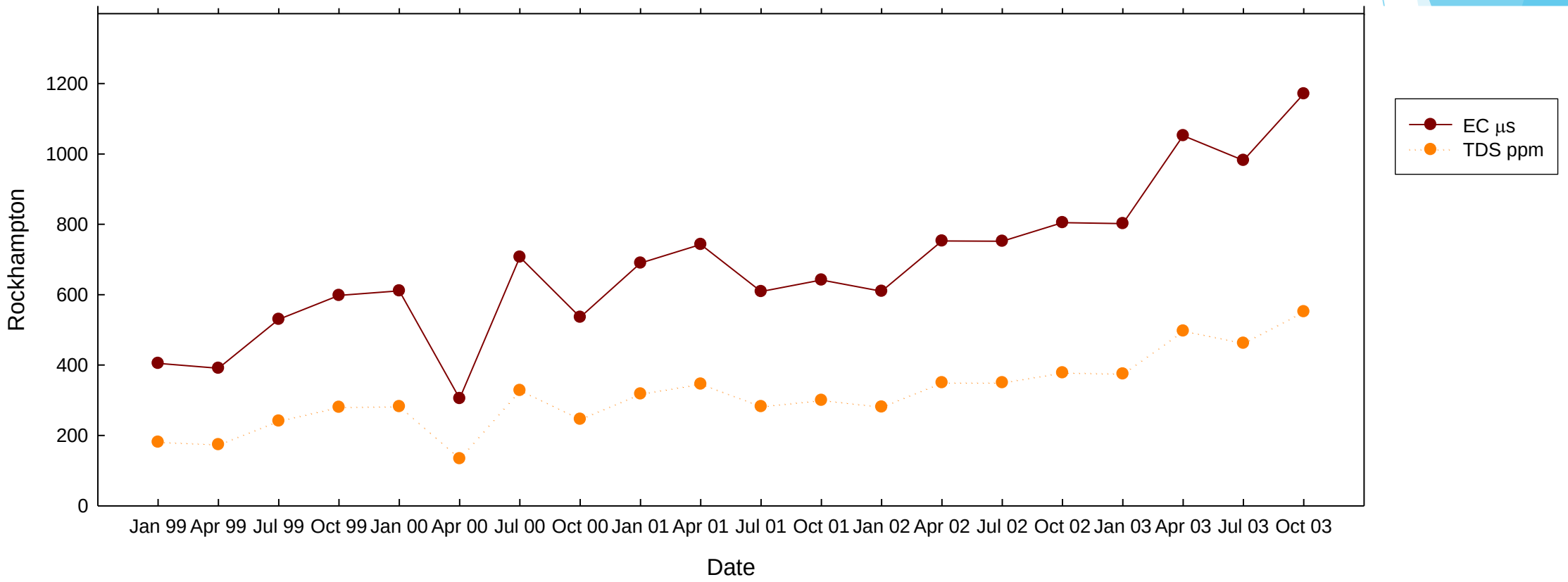
The effect of calcium and sodium ions on soil particles (Asano et al., 2007)

Sodium Adsorption Ratio (SAR)

- The sodium absorption ratio (SAR) is the comparison of the relative preponderance of dissolved sodium (Na^{+}) ions in water to the concentrations of dissolved calcium (Ca^{2+}) and magnesium (Mg^{2+})
- The soil type in the proposed irrigation area is also very important.
  - Sodicity has the most impact on heavy clay soils and the least effect on sands



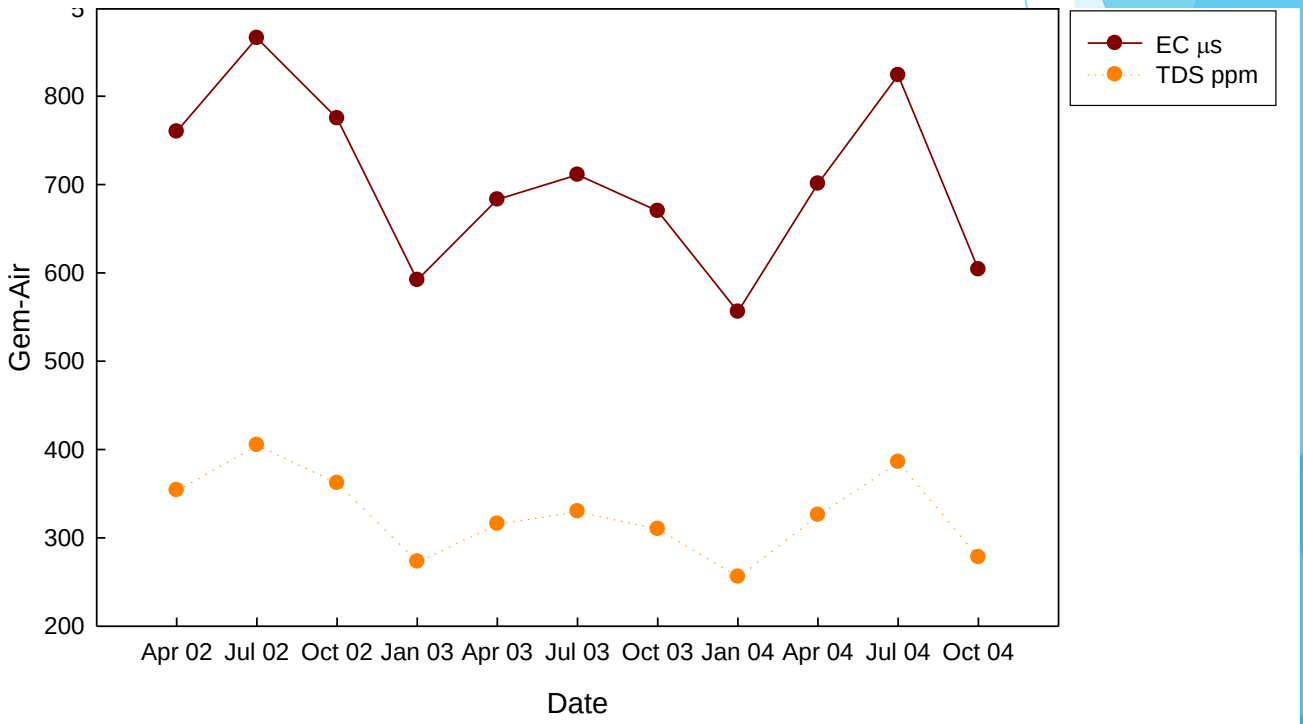
Salinity Accumulation



Frogs in the Toilet are a ‘Thing’

That's Odd…

- The last research site did not accumulate salinity in the same manner as the other 6 sites
  - The SAR also did not rise over time
- Treating similar types of wastewater
- The last research site had some 'issues' and one change was made to the design



The Difference in Salt Damage to Bamboo

What was Different in the Construction?

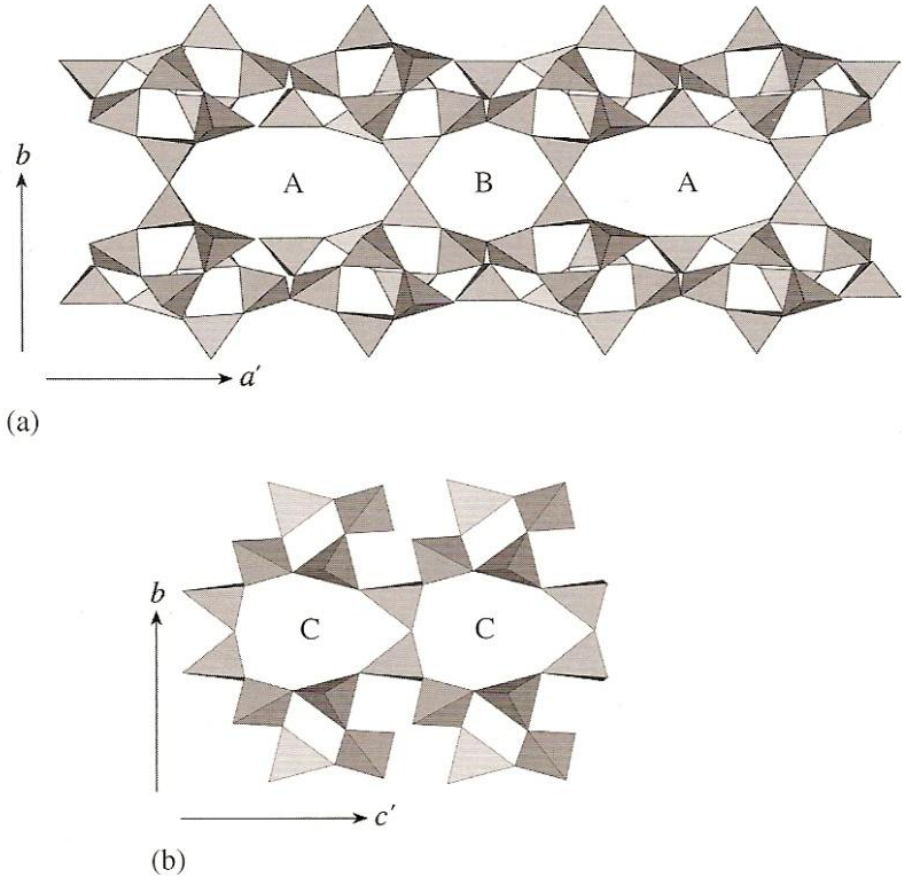
Mixed Ion Exchange and Adsorption Media

Volcanic Media

- Two main types:
  - Zeolite and Scoria
  - Also known as pyroclastic rocks
- Zeolite from the melt mix inside of the volcano
- Scoria from the cone around the surface of the volcano
- Commonly formed from basalt
- Both types of rock can ion exchange and absorb selected chemicals
  - Mostly cations
- Zeolite has an aluminum-silicate framework that acts as a molecular sieve
- Scoria also has aluminum-silicate framework but typically has air holes through the structure

Cation Selectivity Capacity

- For example for clinoptilolite one of its reference cation selectivity is as follows (Mumpton, 1999):
- Cs > Rb > K > NH_4 > Ba > Sr > Na > Ca > Fe > Al > Mg > Li
- Parts of the structure of clinoptilolite with large channels A, B and C: sourced from (Wenk and Bulakh, 2004)



Volcanic Media

Compound	Red Scoria	Black Scoria	Qld Zeolite
SiO_2%	47.2	45.3	68.9
Al_2O_3 %	15.1	12	12.1
TiO_2 %	3.52	1.4	0.22
Fe_2O_3 %	13.1	10.7	1.38
MgO %	5.67	15.5	0.99
CaO %	8.99	8.43	2.8
Na_2O %	3.35	1.81	1.91
K_2O %	1.38	0.76	0.84
MnO %	0.16	0.17	0.05
P_2O_5 %	0.53	0.41	0.06
L.O.I.[a] %	1.74	3.3	11.2

Volcanic Media

- Ran a series of bench trials
  - Minimum of triplicate
- Used different sources of real world high SAR water that had varying salinity
  - Trace chemicals
- Did single media and dual media trials in different formats
- Also tested some non-volcanic media
- Looked at major cations, nitrogen and phosphorus, pH, & salinity

TradeMutt & TIAC

- Trademutt
  - Mental Health Initiative
  - Suicide prevention
  - https://trademutt.com/
- TIACS
  - Mental Health Charity

Red Scoria

Parameter	Ca mg/L	K mg/L	Mg mg/L	Na mg/L	SAR
STP Effluent	11.6	26.61	3.13	354.31	23.8
RO Values	0.23	0.01	0.49	0.04	0.0
Average Red Scoria	10.55	10.94	6.52	308.61	18.5
Standard Deviation	0.76	0.68	1.63	6.53	1.3
Red Scoria RO	0.79	0.01	1.49	43.57	6.7

Black Scoria

Parameter	Ca mg/L	K mg/L	Mg mg/L	Na mg/L	SAR
STP Effluent	11.6	26.61	3.13	354.31	23.8
RO Values	0.23	0.01	0.49	0.04	0.0
Average Black Scoria	58.58	9.81	38.33	152.85	3.8
Standard Deviation	1.78	0.45	1.33	4.35	0.2
Black Scoria RO	2.24	0.01	1.90	4.51	0.5

Qld Zeolite

Parameter	Ca mg/L	K mg/L	Mg mg/L	Na mg/L	SAR
STP Effluent	11.6	26.61	3.13	354.31	23.8
RO Values	0.23	0.01	0.49	0.04	0.0
Average Qld Zeolite	37.37	5.51	14.37	175.44	6.2
Standard Deviation	1.53	1.82	1.02	5.85	0.22
Qld Zeolite RO	0.63	0.01	1.19	21.61	3.7

Non-Volcanic Media: Concrete Rubble

Filter media	Ca mg/L	K mg/L	Mg mg/L	Na mg/L	SAR
STP Effluent	11.61	26.61	3.134	354.32	23.8
Concrete Rubble A	271.20	55.68	0.02	338.30	5.7
Concrete Rubble B	318.70	65.53	0.02	320.40	4.9
Concrete Rubble C	321.63	67.86	0.02	341.24	5.2
Concrete Rubble D	316.83	69.81	0.02	322.24	5.0
Average Concrete	307.09	64.72	0.02	330.55	5.2
Standard Deviation	24.01	6.28	0.00	10.75	0.4
Concrete Rubble RO (run 1)	489.81	32.08	0.02	19.95	0.3
RO Values	0.23	0.01	0.49	0.04	0.0

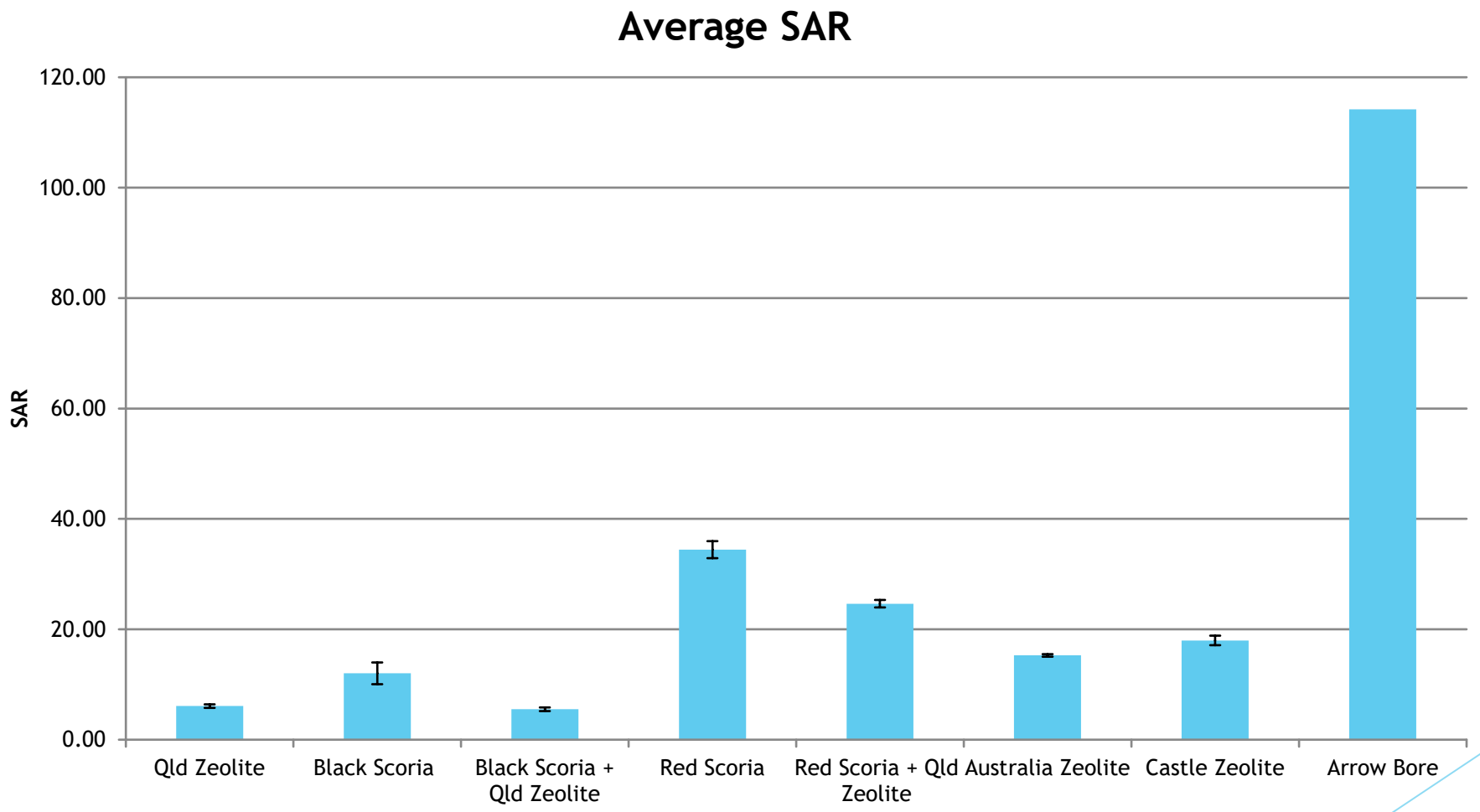
Non Volcanic Media: Clay Beads

Filter media	Ca mg/L	K mg/L	Mg mg/L	Na mg/L	SAR
STP Effluent	11.61	26.61	3.13	354.30	23.8
Clay Beads A	13.30	22.65	0.65	292.20	21.2
Clay Beads B	14.18	24.66	2.55	292.80	18.8
Clay Beads C	14.27	26.24	2.59	283.40	18.1
Clay Beads D	14.55	25.17	3.71	294.70	17.9
Average Clay Beads	14.08	24.68	2.38	290.78	19.0
Standard Deviation	0.54	1.50	1.27	5.03	1.53
Clay Beads RO (run 1)	5.64	5.27	1.74	9.83	0.93
RO Values	0.23	0.01	0.49	0.04	0.0

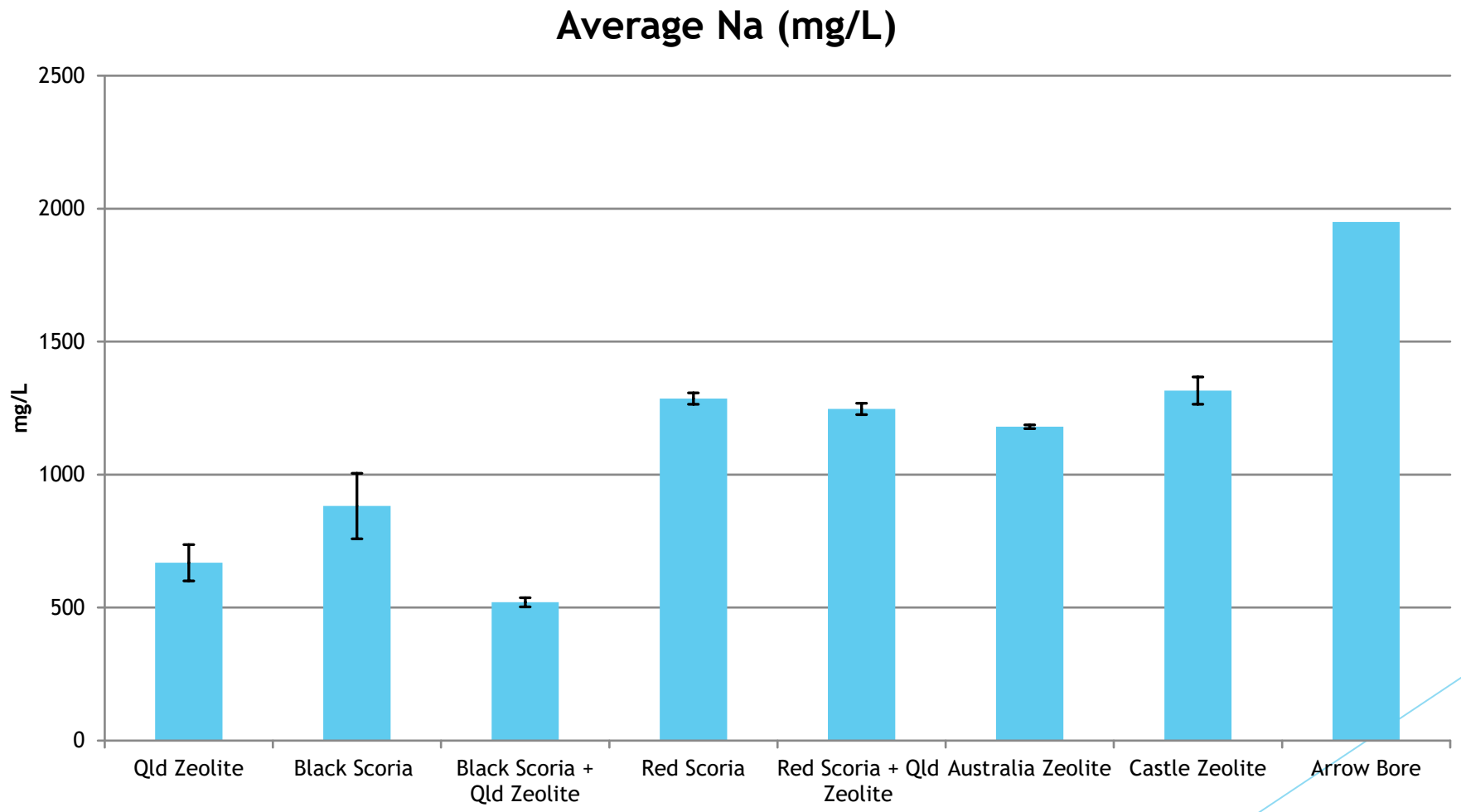
Volcanic Media Results

- Analysis shows that ion exchange is occurring
- Different media has different cation selectivity preferences
  - Can change over time in a individual quarry/mine
- Different media can leach cations that influence SAR but this has a short effective life span
- Standard deviation can be relatively high on 1st flush
- Using different types of volcanic media in stages can be very effective and reduce variation

Mixed Media Results



Mixed Media Results



Sample/Analysis	Na mg/L	K mg/L	Mg mg/L	Ca mg/L	SAR	NH_4 mg/L
Pump-well	112.2	22.6	2.4	9.8	8.3	65.2
Zeolite Tank 1	61.3	1.1	9.9	22.3	2.7	4.9
Zeolite Tank 2	59.4	1.3	11	22.9	2.6	3.8
Pump-well	120.8	22.3	2.1	8.6	9.6	69.9
Zeolite Tank 1	58.6	0.9	10.3	23.5	2.5	4.8
Zeolite Tank 2	66	1.3	11.1	22.1	2.9	4.2
Pump-well	125	22.6	4.1	7.7	9.1	87.6
Zeolite Tank 1	57.6	0.9	9.8	22.6	2.5	4.9
Zeolite Tank 2	63	0.9	8.4	23	2.9	4.4
Pump-well	110.4	21.9	5.5	11.3	6.7	92.6
Zeolite Tank 1	61.1	1.1	9.8	22.9	2.7	4.5
Zeolite Tank 2	62.3	0.9	9	21.6	2.8	4
Pump-well	119.2	21.8	4.8	8.9	8.0	74.2
Zeolite Tank 1	64.2	1.1	10.2	22.3	2.8	4.6
Zeolite Tank 2	59.8	0.8	10	22.3	2.6	4.2

Media May Be Required in Bulk

Media May Require Regeneration or Replacement

Replacement May Be Difficult

Proper Planning for Media Replacement

Conclusion

- Its not ‘magic’ media, the treatment is based upon cation exchange principles and for some chemicals adsorption
- Highly variable depending on the source water and the specific volcanic media/s being used
- Mass balance calculations are required to size appropriately;
  - Need tons not pounds…
- Can be regenerated but won’t last for ever