Pool and Tap Water Survey
A multi-element Study of Tap and Pool Water in Pima County, Arizona

Que Hales
Pool Chlor
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This survey provides a detailed examination of actual pool water and tap water samples from private pool owners in Pima County, Arizona. The analytes include calcium, magnesium, iron, manganese, copper, zinc, silica, fluoride, chloride, chlorine, chlorate, chlorite, nitrate, nitrite, phosphate, sulfate, bromide, bromate, pH, alkalinity and cyanuric acid. The data is illustrated to provide comparisons of pool and tap waters, as well as those relationships that exist with such factors as NSPI standards, TDS, water balance, pool water age, sanitation types and environmental issues.

History

There are few published surveys that describe extensive details about the components of swimming pool waters. One study by Beech, Diaz, Ordaz & Palomeque (Beech et al. 1980) focused only on nitrates, chlorates & trihalomethanes. In another study by The Pinellas County Public Health Unit and Occidental Chemical Corporation (Pinellas County 1994) pools were tested for pH, chlorine, cyanuric acid and bacteria. In each case the study was limited to a select few components.

Objective

This survey of water provides a comprehensive picture for twenty–three components from a large sampling of pool and tap waters. This study illustrates the hypothesis that pool water quality is a function of the following factors:

- Tap water quality
- Added chemicals
- Evaporation
- Environmental factors
  - Bather waste, run–off, lechates from pool system, by–products of disinfection, and precipitation.

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Pages 46–56

Analytical Methods

Component	Method
Anions	Ion Chromatography
Metals	ICP–OES
Total Dissolved Solids	Conductivity Meter
Total Chlorine	Iodometric titration
Cyanuric Acid	Turbidity
pH	pH meter
Total Alkalinity	Base titration
Hardness	EDTA titration and ICP–OES

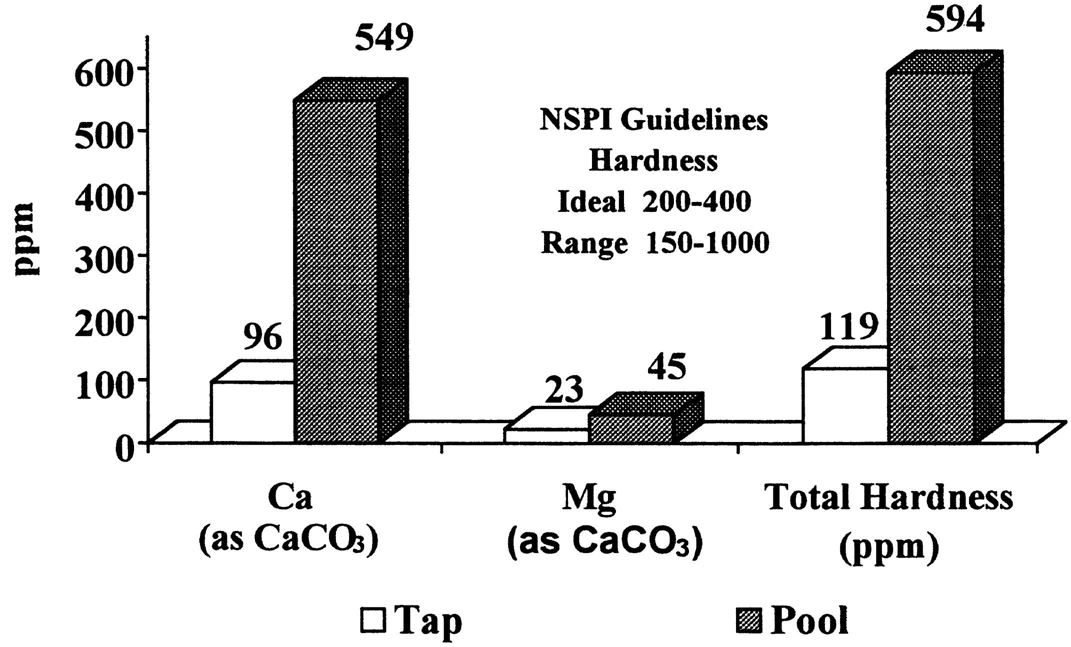
Water Components Analyzed and Method Detection Level (MDL)

The MDL is based on routine laboratory analysis of these components in a pool water matrix and would be considered the practical quantitation limit. Extraction and concentration procedures were not used.

Component	MDL		
PH	NA	Manganese	1 ppb
Bromide	0.05 ppm	Total Dissolved Solids	1.0 ppm
Calcium	0.02 ppm	Fluoride	0.04 ppm
Total Alkalinity	2.0 ppm	Copper	3 ppb
Bromate	0.06 ppm	Hardness	0.1 ppm
Magnesium	0.01 ppm	Chloride	1.0 ppm
Chlorine	0.1 ppm	Silica	0.10 ppm
Phosphate	0.07 ppm	Nitrite	0.04 ppm
Iron	2 ppb	Chlorite	0.04 ppm
Cyanuric Acid	10.0 ppm	Zinc	3 ppb
Sulfate	0.2 ppm	Nitrate	0.10 ppm
		Chlorate	0.05 ppm

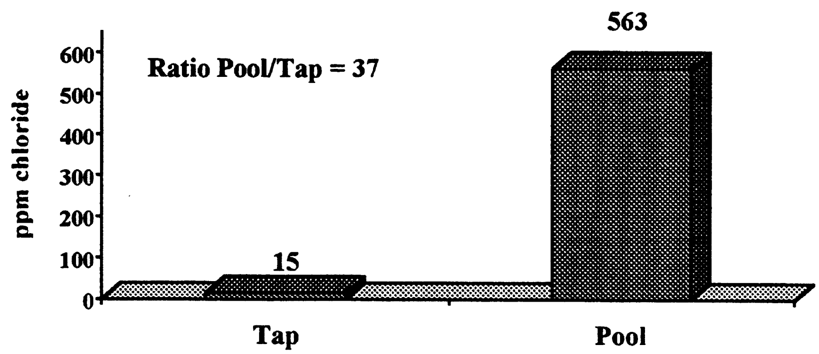
Results and Discussion

Hardness



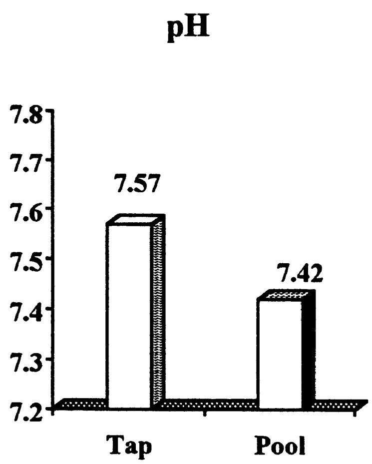
It is evident that calcium is the significant component for water hardness in pool water. Magnesium has a greater contribution in tap water and is concentrated in pool water through evaporation. Sometimes calcium chloride is added to increase hardness. Use of calcium hypochlorite as the primary sanitizer can also increased the hardness. The average pool water hardness is well above the NSPI ideal concentration, but within the accepted range.

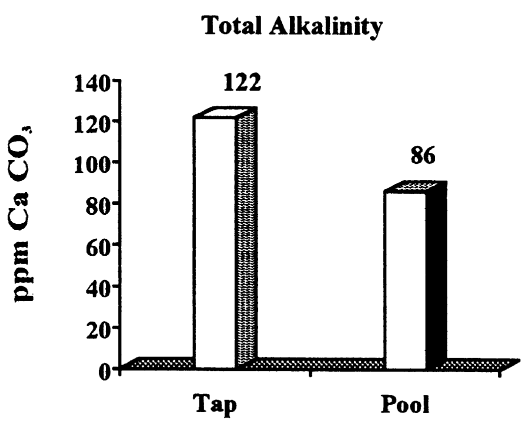
Chloride



A calculation of the chloride and calcium data suggests that about 70% of the chloride present in the pool water is from calcium chloride and 6% from magnesium chloride. Much of the remaining chloride, 135 ppm, is most likely from chlorine decomposition.

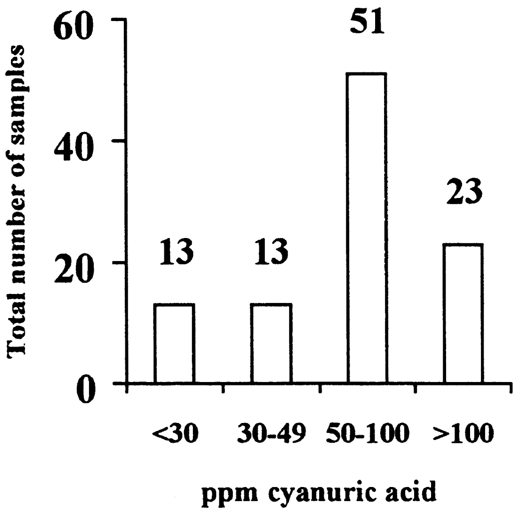
pH and Total Alkalinity





The average pH and total alkalinity values are acceptable.

Cyanuric Acid

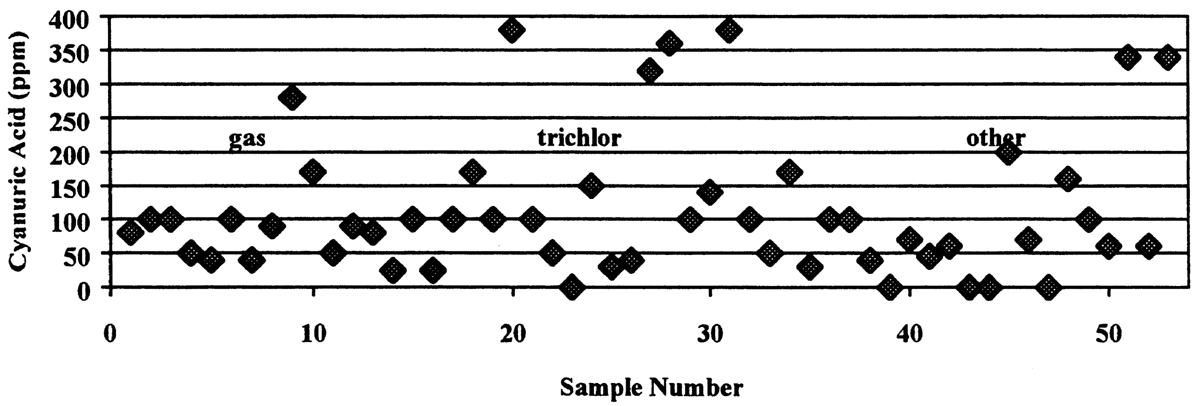


Cyanuric Acid

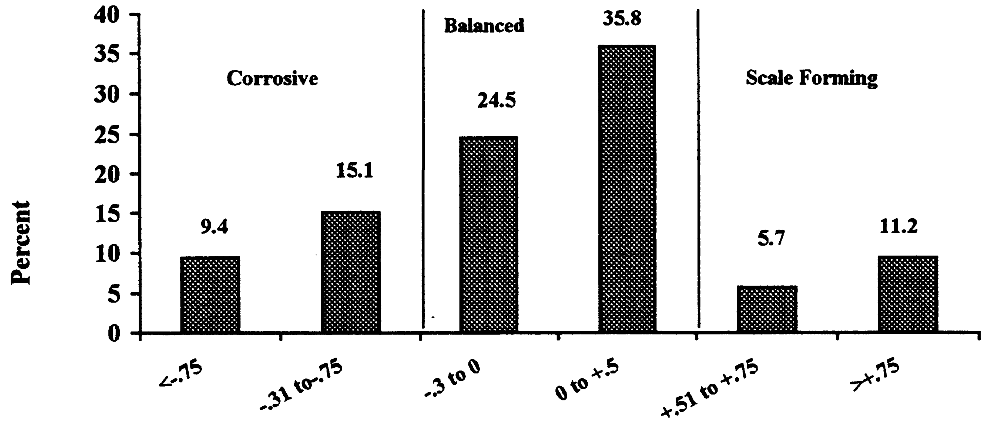
Average	105 ppm
Low	0
High	*380 ppm*
NSPI range	*30-50 ppm*
Target for gas pools	*100 ppm*

The average cyanuric acid concentration is extremely high. In fact more than 80% of the pools have concentrations significantly higher than the suggested NSPI range. One factor is that gas chlorinated pools are maintained with higher concentrations of cyanuric acid. About 13% of the surveyed pools have insufficient cyanuric acid. This would suggest inadequate pool water maintenance.

Other causes for high cyanuric acid levels may be from the exclusive use of trichlor. Almost 45% of the pools routinely use trichlor. The following chart illustrates the cyanuric acid concentration compared with sanitizer use.

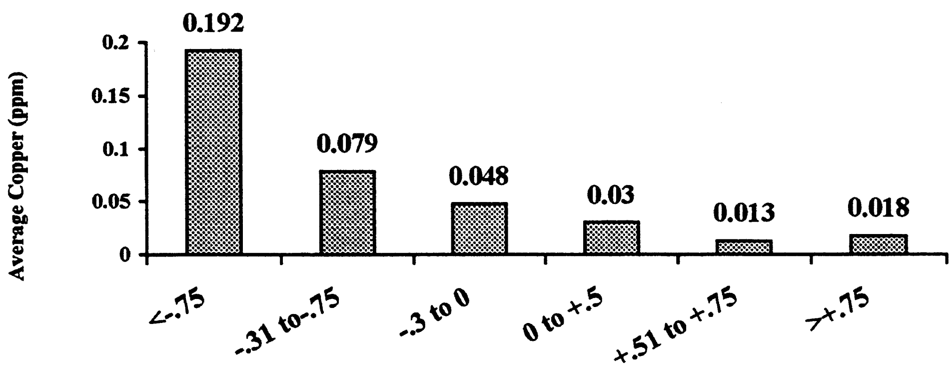


Langelier Saturation Index for Pool Water



5.1 Langelier saturation index and copper concentration in pool water.

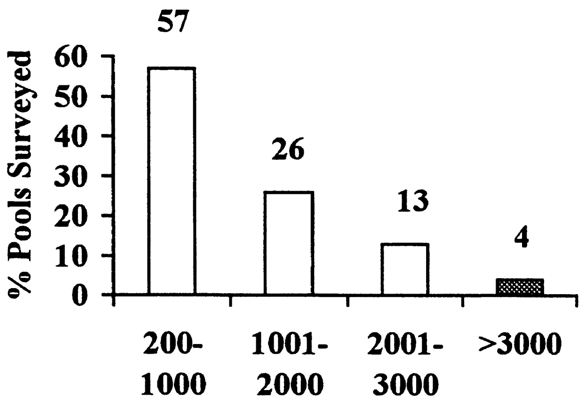
More than 60% of the surveyed pools had an acceptable Langelier saturation index, the water was neither corrosive nor scale forming. The copper content of the pool water had an interesting correlation to the Langelier index. The surveyed pool water had an average concentration of 0.055 ppm copper.



Pool water with a low Langlier index will be corrosive in nature and according to this survey does contain more copper than balanced water and especially scale forming water.

Copper from tap water (.036 ppm) may tend to build up more readily in corrosive pool water. In addition, many pools in this geographical area have heaters with copper coils.

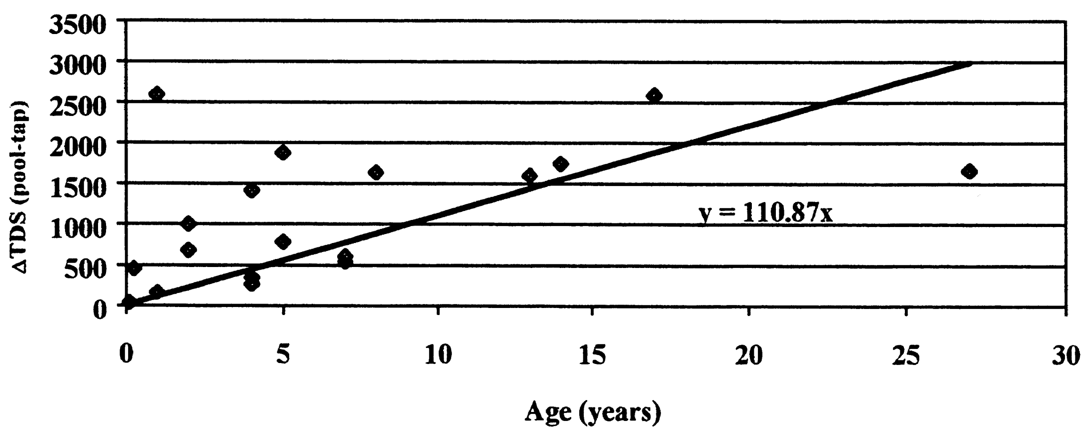
Total Dissolved Solids



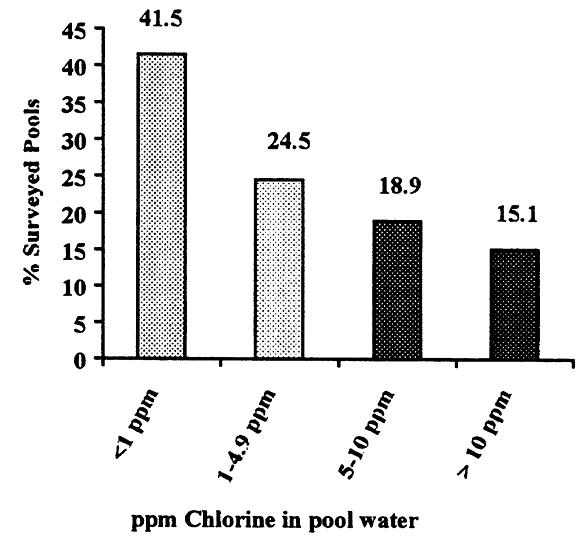
TDS (ppm)	
Average	1231
Low	220
High	3590
Tap Average	196
NSPI, max	1500 above tap

Average TDS for the surveyed tap water was 196 ppm. This would suggest that an acceptable maximum TDS should be about 1696 ppm. Almost 25% of the surveyed pools have a TDS greater than this value. Since increasing TDS is a factor of pool water age we examined the data for a correlation.

There was limited information regarding pool water age. Only eighteen (34%) of the surveyed owners provided an answer to the question of pool water age.

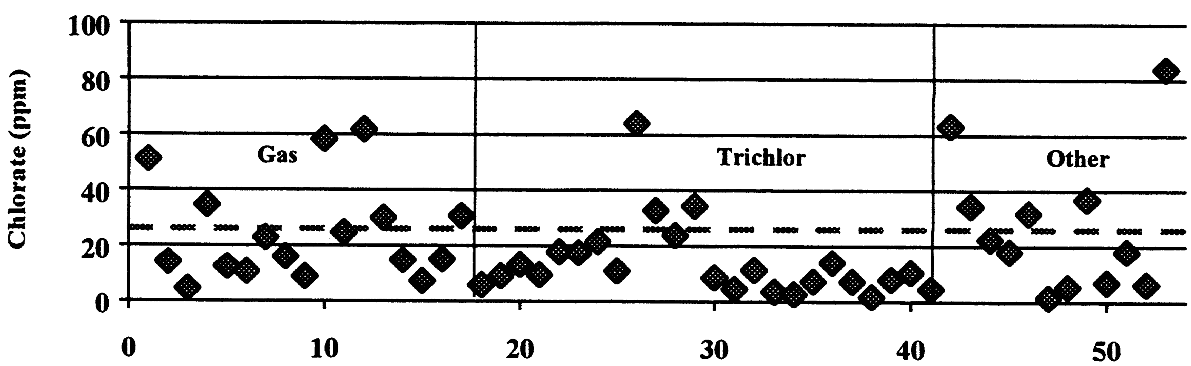


Total Chlorine



Total Chlorine (ppm)	
Average	*4.1*
Low	*0*
High	*16.5*

Almost 25% of the surveyed pools had no detectable total chlorine. In addition, chlorate concentrations were significant. The average value of chlorate in the surveyed pools was 21 ppm. This data was examined for correlation to sanitation type.



Every pool had chlorate. Chlorate formation occurs due to the decomposition of hypochlorite (chlorine), or as a contaminant in chlorine.

$$\underset{\textit{hypochlorite}}{2\,OCl^-} \xrightarrow[\textit{slow}]{\textit{decomposition}} \underset{\textit{chlorite}}{ClO_2^-} + \underset{\textit{chloride}}{Cl^-}$$

$$\underset{\textit{hypochlorite}}{OCl^-} + \underset{\textit{chlorite}}{ClO_2^-} \xrightarrow[\textbf{fast}]{\textit{uv light, } \uparrow pH \textit{ etc.}} \underset{\textit{chlorate}}{ClO_3^-} + \underset{\textit{chloride}}{Cl^-}$$

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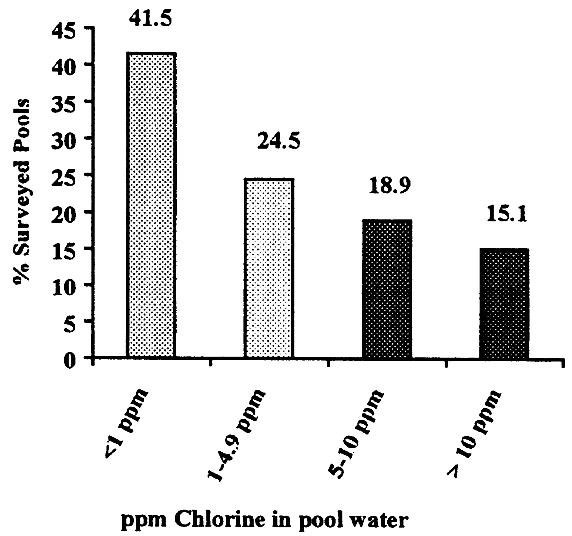

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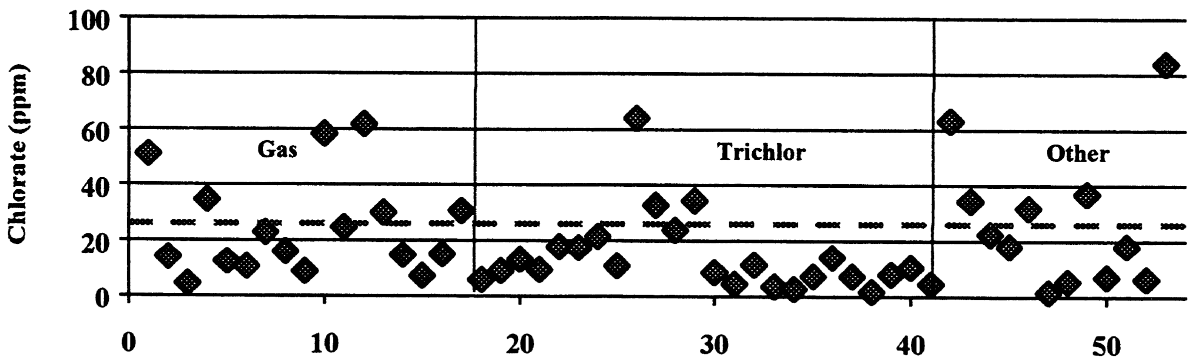

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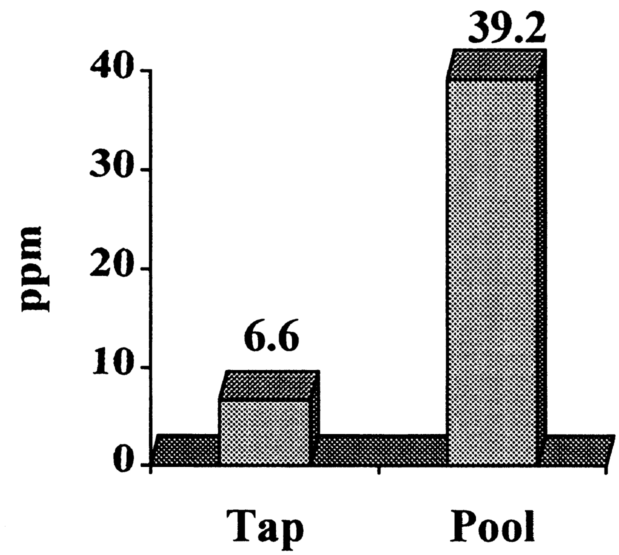
Nitrate and Nitrite



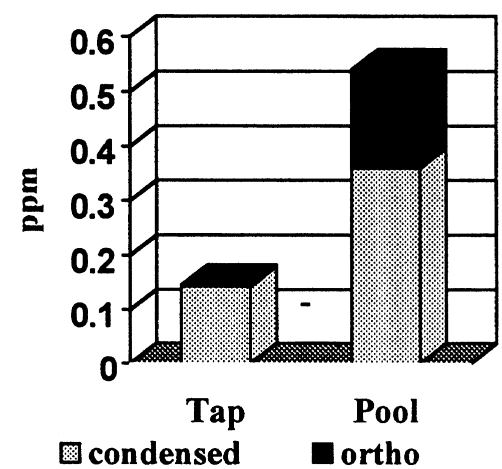
Tap water from Pima County has significantly high nitrate concentrations due to excessive agricultural run-off. Nitrite concentration is insignificant.

Nitrate will build up in pools due to the following;
- Oxidation of bather waste.
- Concentration due to evaporation.

The process by which nitrate builds up in pool water is described in the following equation. Nitrite is rapidly oxidized to nitrate by *free chlorine.*

$$\underset{\text{nitrite}}{NO_2^-} + HOCl \longrightarrow \underset{\text{nitrate}}{NO_3^-} + Cl^-$$

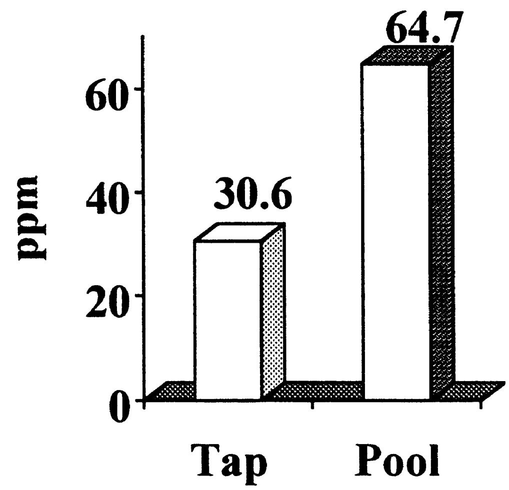
Phosphates



Phosphates are a problem in pool water because they promote algae growth. 72% of the sampled pool water population contained o-phosphate at an average concentration of 0.18 ppm. There is a significant concentration of condensed phosphate, 0.36 ppm (expressed as o-phosphate). Condensed phosphate can decomposed into o-phosphate.

Phosphates are found in the tap due to minerals from the ground water and agricultural run-off. Pool water will build up phosphates from tap water and lawn fertilizer run-off. Another surprising source of phosphates are pool chemicals, such as descalers and chelating agents

Silica



The silica concentration is significant in the Pima County tap water. This may be due to excessive groundwater minerals, or silicate may be added by the municipalities as a corrosion inhibitor.

11.0 Metals and Oxidation of Metals with Chlorine.

The surveyed tap water samples contain on average 0.5 ppb manganese and 9.7 ppb iron. These concentrations are very small and do not pose a significant staining potential. There was no detectable iron or manganese in the pool water samples. This is due to the oxidation of metals by chlorine. The following equation provides the mechanism by which the metals were removed.

$$Mn^{+2} + HOCl \xrightarrow{\text{pH 7–8, bicarbonate}} MnO_2\downarrow + Cl^-$$

$$Fe^{+2} + HOCl \xrightarrow{\text{pH 7, excess bicarbonate}} Fe(OH)_3\downarrow + Cl^-$$

Data for all other components.

Some water components were not discussed in this report. The following table provides a look at the occurrence of those remaining components and the average concentration as a function of the occurrence.

Component	Average Concentration Tap	Average Concentration Pool	Occurence Tap	Occurence Pool
Fluoride (ppm)	.26	.63	100%	100%
Sulfate (ppm)	36.0	142.8	100%	100%
Chlorite (ppm)	.015	.191	3.8%	62.3%
Zinc (ppb)	85.0	22.9	43.4%	45.3%
Nitrite (ppm)	.02	.25	9.4%	49.0%
Bromide (ppm)	.06	.03	89.0%	1.9%
Bromate (ppm)	.01	1.02	1.9%	47.0%

Summary

Pool water contains higher concentrations of all tested components, except for iron and manganese. Chlorate had the highest increase in concentration. Although evaporation of tap/fill water is a major contributor to higher concentrations of components in the pool water, the following table provides a list of potential causes of build up.

Contaminant	Ratio Pool/Tap	Causes
Chlorate	188	– Decomposition of hypochlorite – Contaminant in chlorine source
Phosphate	75	– Sequesterants – Agricultural run–off
Chloride	37	– Calcium hardness adjustment – Chlorine decomposition
Calcium	7.5	– Hardness adjustment – Calcium hypochlorite – Gunite plaster leachates
Nitrate	6	– Oxidation of bather waste

References

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About the Contributors

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