Relationships Between Some Variables Affecting Pool Water Quality

Dick Vattimo
Occidental Chemical Corporation

In 1992 the Pinellas County Florida Public Health Unit under the direction of D. Michael Flanery, PE, Environmental Engineering Division Director, measured various properties of 486 public pools. Data was collected in the following categories: bacteria populations, water chemistry, turbidity, type of sanitizers used, environmental conditions (bather load, weather etc.), swimming pool characteristics, time and algae. The data was statistically analyzed under the direction of Dr. Lawrence Rakestraw (retired) of Occidental Chemical Corporation. This talk will describe the variables measured and their relationships to each other.

Note: These Lists, Figures and Tables are best understood in conjunction with the audiocassette recording of the presentation. Please see page 6 for order information.

Background

- Study Done July–November 1992
- Public Pools in Pinellas County, FLA.
- Principal Authors
  - D. Michael Flanery, PE, Environmental Engineering Division Director, Pinellas County
  - Lawrence F. Rakestraw, Ph.D., Technical Service Manager, Occidental Chemical Corporation (Ret.)

The study was done in Pinellas County because:

1. There are a large number of public pools located there, about 10% of all of the public pools in Florida.
2. The swimming season is longer in Florida than most of the rest of the country.
3. It is difficult to maintain the proper disenfection conditions in Pinellas County pools because of the hot, rainy weather and high bather load.
4. The results of this study could be used to confirm the results of a previous study done in 1973-1981.

Samples and Analysis
(See Figure 1)

Two samples were taken from each pool, 1 was tested for various water quality parameters, some at pool side and others in a laboratory. The other sample was dechlorinated to prevent any further killing of bacteria, iced and bacteria testing was done within 24 hours. Other pool observations and parameters were also recorded such as turbidity and whether there was any rain in the last 24 hours.

Coded Variables

- Turbidity None=1, Cloudy=5
- Algae
- Rain Last 24 hrs. None=1, Heavy=4
- Water Return System
- Day of the Week–Sunday=1, Thursday=5
- Month July=7, November=11
- Pool Surface Condition Good=1 Poor=3

Variables need to be coded into numerical values when the readings are non-numeric because the correlation equations will work with numbers only. Some of the coded variables are listed. The numbers

Proceedings of the 2nd Annual Chemistry Symposium
National Spa and Pool Institute – November 1997
Pages 89–93

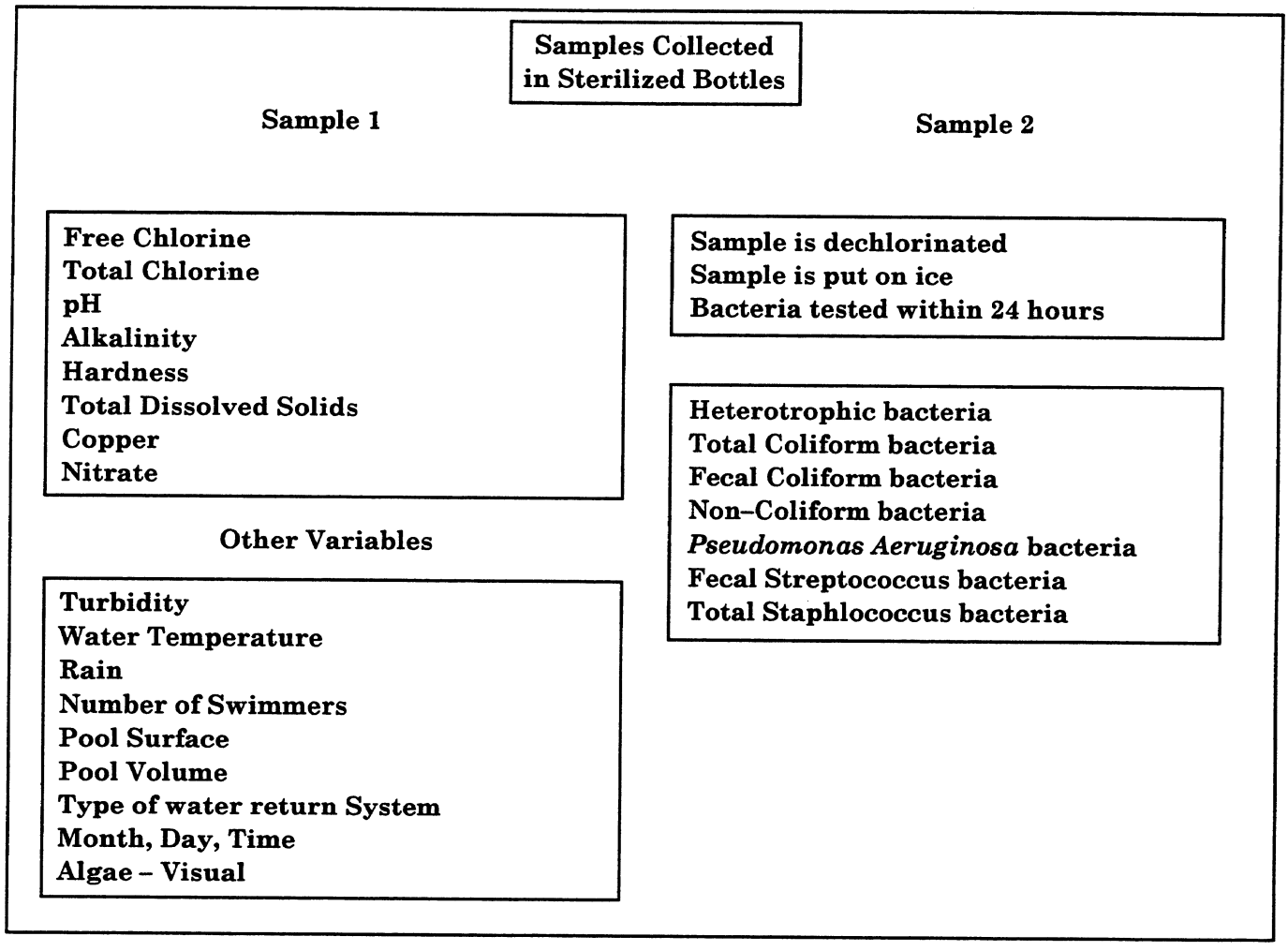

Figure 1 – Samples and Analysis

are arbitrary, but in general we used lower numbers to show the absence of the parameter. Some of the problems with using coded variables are:

1. In some cases the numbers assigned may not be linear. A reading of 5 (cloudy) for turbidity is not necessarily 5 times as turbid as a reading of 1 (none).

2. The numbers are not continuous-e.g. a number of 2.5 cannot exist for turbidity.

3. Some of the observed variables like turbidity, algae and pool surface condition are subjective and more subject to differences between observers.

What We Don't Know About the Variables and Pools

- Condition of the Filter
- Filter Operation and Maintenance
- Analytical and Sampling Variability
- Pool Usage
- When Pool was Shocked
- Pool History

Although a large amount of data was collected on the 500 pools, there is data associated with the pools and samples that we do not have. The list is an example of some of that information. In addition we do not know water turnover rates, pump information, pool configurations, pool surface area, any drainage information and fresh water addition and any testing data compiled by the pool operator and other log book information.

Correlation

- Measures the relationship between 2 sets of paired numbers. Can be Positive or Negative
- If 1 number can be predicted as a function of another then the numbers are correlated
- F temperature and C temperature
- Height and Weight
- Height and Age

Correlation coefficients are derived using mathematical equations on corresponding pairs of num-

bers, the magnitude of the coefficient is used to decide if there is a relationship between the 2 sets of numbers within a predetermined probability of being correct. In the above examples.

1. Temperature scales Fahrenheit and Celsius are correlated, if the F temperature rises the C temperature rises and vice versa.

2. There is a correlation between height and weight and height and age. In general the taller someone is, the more they weigh. This is particularly true for ages 0-16. Height and age are also correlated, but again much more during a person's period of growth. Just because there is a correlation doesn't mean that there are not exceptions in many cases. We all know of cases where the height correlations do not apply.

Correlation/Cause and Effect

- Always Want to Use Correlations to Explain Cause and Effect
- Smoking and Lung Cancer
  - Picking up matches in restaurants
  - Ashtrays in houses
  - Composition of cigarettes
- Temperature Between September and December and Toy Sales

The main use of correlations is to determine if there is a cause and effect relationship between the numbers. We often hear about correlations related to health issues. Coffee and high blood pressure, sugar and cavities etc. The correlation that is receiving a large amount of attention today is the relationship between smoking, lung cancer and other diseases. The same conclusions could be drawn from observing people who pick up matches in restaurants and have ashtrays in their houses. We could conclude that those activities cause lung cancer. However in reality there is another underlying cause that is present. If someone came to Chicago from Mars and wanted to determine when to sell toys and they measured the temperature from September through December they would quickly conclude that the colder it was the more toys you would sell. Obviously the real cause and effect is Christmas and toy sales.

Correlation Statistics

- Ranges from –1 to +1 (Perfect Negative to Perfect Positive: 0= No Correlation)
- Random Pairs of Numbers
- 1/2 of Room vs the Other 1/2
- Criteria Used–Less than 5% Probability that Correlation Could Occur by Chance Alone

1. The correlation coefficient is not linear, so a positive correlation of .4 is not twice as good as .2.

2. If we generate pairs of random numbers by chance alone we could have a slight correlation between them. It would be false since if the numbers were truly random there could not be a relationship between them.

3. If we divide this room in half and have 2 people from each side of the room give their height with the following results:

Side 1 Person 1 5'11"	Side 2 Person 1 5'8"
Side 1 Person 2 6'2"	Side 2 Person 2 5'6"

Using this data alone we could conclude that there is a negative correlation between the height of the people on side 1 versus side 2. That is as the height of the people on side 1 goes up, the height of the people on side 2 goes down. This is one of the dangers of correlation analysis, if the sample size is too small, erroneous conclusions will happen.

4. The acceptance criteria used in this study was that there was a 95% confidence that the correlation coefficient was not generated by chance (random numbers) alone.

Free Chlorine Correlations

POSITIVE
- Cyanuric Acid
- Total Chlorine

NEGATIVE
- # of Swimmers
- Heterotrophic Plate Count
- Total Coliform
- Non–Coliform
- Hour of Day
- Day of the Week
- Month
- Turbidity
- Black Algae

This is the first group of correlation statistics generated from the pools. They are interpreted as follows:

1. Positive correlations: As the concentration of free chlorine goes up, the amount of cyanuric acid goes up.

2. Negative correlations: As the concentration of free chlorine goes up, the amount of total coliform bacteria goes down.

The rest of the correlations are interpreted in the same way.

pH Correlations

POSITIVE
- Total Staphlococcus Bacteria
- Date–Higher in the Fall
- Hour of the Day
- Alkalinity

NEGATIVE
- Cyanuric Acid
- Temperature
- Day of the Week
- Surface Condition

Alkalinity Correlations

POSITIVE
- Number of Swimmers
- pH

NEGATIVE
- Surface Condition

Total Dissolved Solids Correlations

POSITIVE
- Heterotrophic Plate Count
- Total Coliform Bacteria
- Total Staphlococcus Bacteria
- Nitrate
- Hardness

NEGATIVE
- Cyanuric Acid

Cyanuric Acid Correlations

POSITIVE
- The Use of Trichlor Tablets
- Free Chlorine
- Total Chlorine
- Surface Condition

NEGATIVE
- Total Dissolved Solids
- pH
- Hardness
- Heterotrophic Plate Count
- Month

Pool Volume Correlations

POSITIVE
- # of Swimmers
- Rain
- Black Algae
- Yellow Algae

NEGATIVE
- Hardness
- Day of the Week

Temperature Correlations

POSITIVE
- # of Swimmers
- Total Coliform
- Non Coliform
- Rain
- Day of the Week
- Turbidity
- Black Algae
- Surface Condition

NEGATIVE
- pH
- Month
- Hour of the Day

Number of Swimmers Correlations

POSITIVE
- Alkalinity
- Temperature
- Volume
- Total Coliform
- Non Coliform
- Fecal Streptococcus
- Hour of the Day
- Turbidity

NEGATIVE
- Free Chlorine
- Total Chlorine
- Hardness
- Day of the Week

Heterotrophic Plate Count Correlations

POSITIVE
- Total Coliform
- Fecal Coliform
- Non Coliform
- Turbidity

NEGATIVE

- Free Chlorine
- Total Chlorine
- Cyanuric Acid
- Total Dissolved Solids

Black Algae Correlations

POSITIVE
- Temperature
- Volume
- Turbidity
- Yellow Algae
- Green Algae
- Surface Condition

NEGATIVE
- Free Chlorine
- Total Chlorine
- Hardness

About the Speaker

Dick Vattimo is a chemist and a 30 year employee of Occidental Chemical Corporation. His career has included positions as an analytical chemist, plant Quality Control Superintendent, Corporate Quality Manager, Technical Service Representative, and Technical Service Manager. He and his group have been involved with pool chemicals since Occidental's purchase of Monsanto's isocyanurate business in 1992.