Application of a Data Processing System to a Swimming Pool Inspection Program

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A DATA handling and processing system, developed by engineers of the Du Page County Health Department, was used to tabulate and report results of the county's swimming pool inspection program in 1963.

Du Page County, Ill., encompassing approximately 340 square miles, had an estimated population of 357,300 in 1962. By the end of the 1963 swimming season, the county contained 46 operating public pools, 7 of which are indoors. Eleven pools have reverse flow and the remainder conventional flow; 11 are heated (most of these were built during the past 4 years); and 22 also have "kiddie," spray, or wading pools.

The types of filter equipment used, according to pool volumes, are shown in figure 1. Pressure diatomite filters are the filters of choice in installations of less than 100,000 gallons of water. Most of the larger pools were built before 1950, when diatomite technology was in its infancy. During recent years, with the trend toward apartment and motel pools, diatomite filters have become popular because of their increasingly attractive cost and efficiency factors. Theoretical filtration rates, based on a 6-hour turnover rate, by type of filtration equipment used are shown in the table.

The kinds of disinfectant used, according to pool volumes, are shown in figure 2. Hypochlorination is generally used for the smaller pools, while gas chlorination is used exclusively for pools holding more than 150,000 gallons of water.

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Evolution of the Program

The Illinois Department of Public Health delegates inspection of public swimming pools to some county health departments. For several years engineers in the Du Page County Health Department inspected this county's pools once a year, and they rated the pools on standard forms supplied by the State health department. The following classification schedule was used to rate the pools: class AA, 95–100 points; class A, 85–95; class B, 75–85; class C, 65–75, and class D, not approved.

In addition to the State program, Du Page County has a public swimming pool ordinance requiring that operation permits for outdoor pools be obtained each year from the county health department and that pools comply with the rules and regulations of the State health department. Initially, our annual inspections were primarily for the purpose of renewing operating permits. In addition we received some monthly operating reports, on an irregular basis, from pool operators. This provided the only available operating information. We also received results of analyses of samples collected by pool operators and submitted semimonthly to the State health department's laboratories in Chicago. These samples were analyzed for coliform, streptococcal, and total bacterial count.

It soon became apparent that rating a pool after only one visit a year had serious shortcomings. Consequently, during the 1960 pool season an employee of the county health department made weekly visits to the 25 existing pools to observe their operating characteristics. This program worked so well that a college engineering student was employed for this purpose during the following two summers. By 1963, however, the increased number of pools necessitated employment of two students. Their comments and findings were recorded on a standard form developed by our engineers. The results of the first 2 years of the students' visits provided a voluminous amount of useful data. But we had no way to tabulate it quickly or to report the results to interested parties.

Data Handling and Processing

An IBM 1401 computer system, recently installed in the county building for tax record accumulation and billing, was made available to the county health department. We therefore developed a system to accumulate, summarize, and report our swimming pool data, and we decided to make the weekly inspection program permanent.

Theoretical filtration rates, based on a 6-hour turnover rate, by type of filtration equipment in swimming pools, Du Page County, Ill.

Filter	Number pools [1]	Filtration rates [2]		
		Average	Maximum	Minimum
Pressure diatomite	22	2. 16	4. 17	0. 70
Vacuum diatomite	9	1. 77	2. 26	1. 26
Pressure sand	8	2. 80	3. 51	1. 87
Gravity sand	5	2. 91	3. 12	2. 72
All pools	44	2. 28	4. 17	. 70

[1] Filter areas for two pools were unknown.
[2] Gallons per minute per square foot of filter area.

Figure 1. Distribution of types of filter equipment, according to swimming pool volumes, Du Page County, Ill.

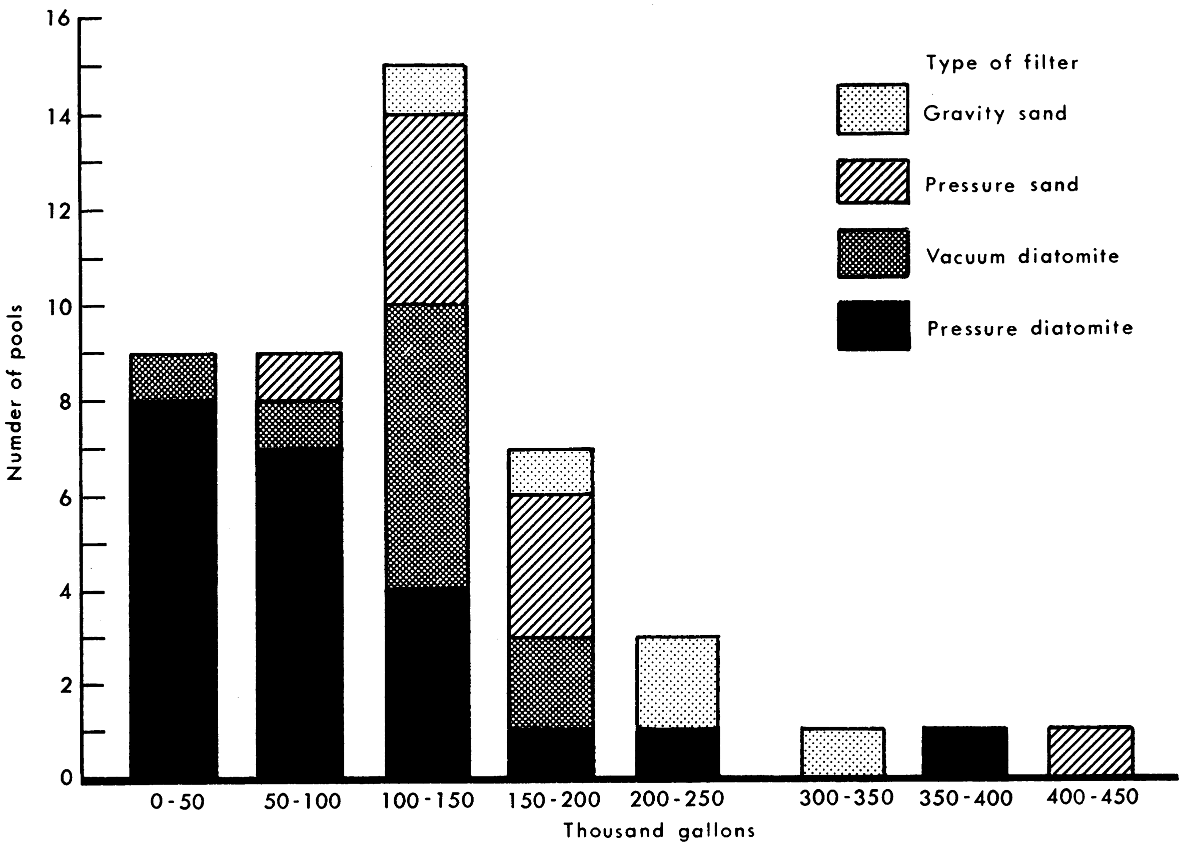
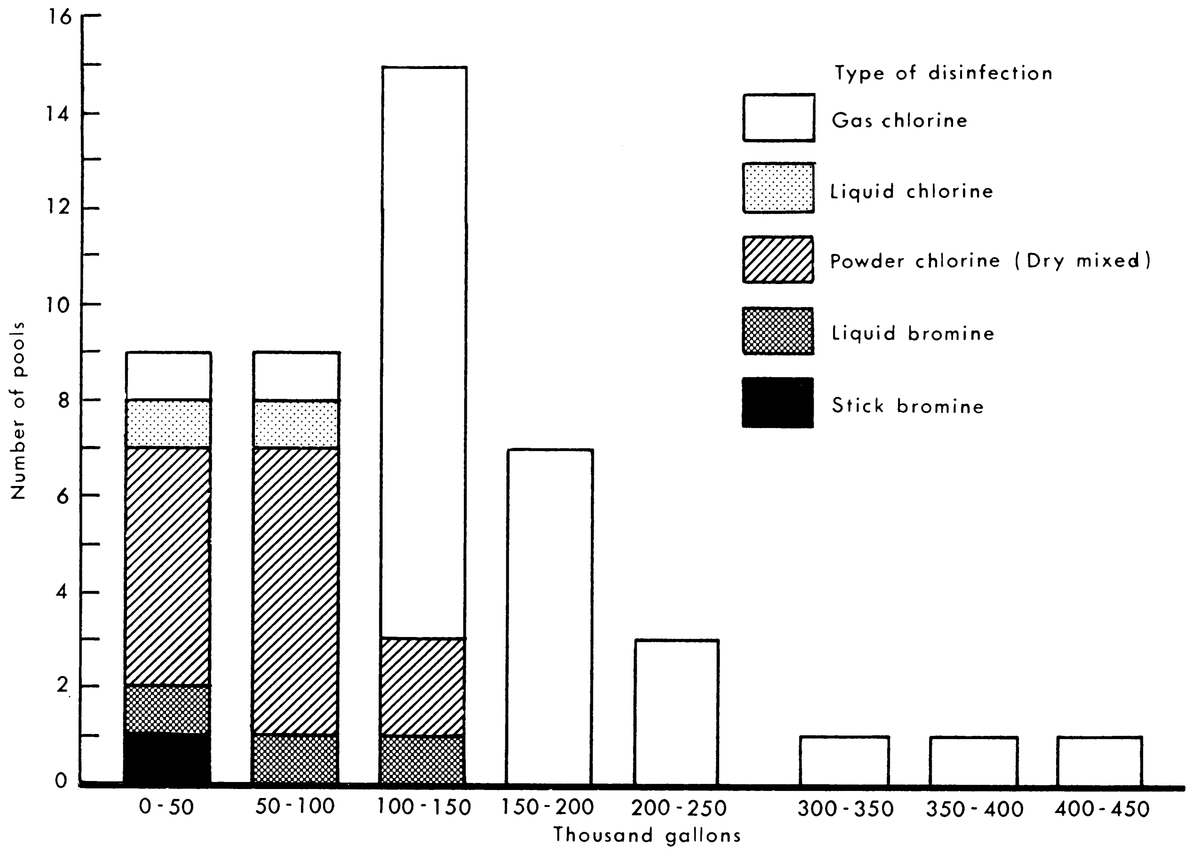


Figure 2. Distribution of types of disinfectants, according to swimming pool volumes, Du Page County, Ill.



The engineering aide now records his observations on a mark sense card. He notes the date and time of the visit, disinfectant residuals at the shallow and deep ends of the pool and wading pool (if any), pH, number of swimmers, and air temperature. He also makes a quantitative judgment as to water clarity and bather inspection, as well as condition of dressing rooms, pool area, spectator area, and toilets and lavatories. He then requests the pool operator to sign the card so there will be no disagreement as to interpretation at a later date.

The information on the mark sense cards is punched onto cards adaptable to the card sorter and computer and tabulated by the computer system. The printouts provide us with a final tabulation of data from all the visits made during the pool season, and we incorporate this tabulation into the annual engineering inspection letter sent to each pool operator or owner.

This system can be adapted to any pool inspection program without the need for expenditures for card sorters, computers, or printers. The mark sense cards, along with proper instructions for the computer system, can be handled by any computer center for a nominal cost.

1963 Results

During the 1963 swimming pool season, two engineering aides made 569 visits to the 46 public pools. A total of 969 bacterial samples were collected and analyzed for coliform, streptococcal, and total bacterial count in accordance with standard methods by the State health deparment laboratories in Chicago. The average number of visits per pool was slightly more than 12, a frequency of about once a week, though one pool was visited 24 times. The most infrequently visited pool, open only part of the season, received five visits. Twenty-six pools were visited from 10 to 15 times during the season. Generally, pools given high ratings in 1962 were visited less frequently than those with low ratings or newly constructed ones.

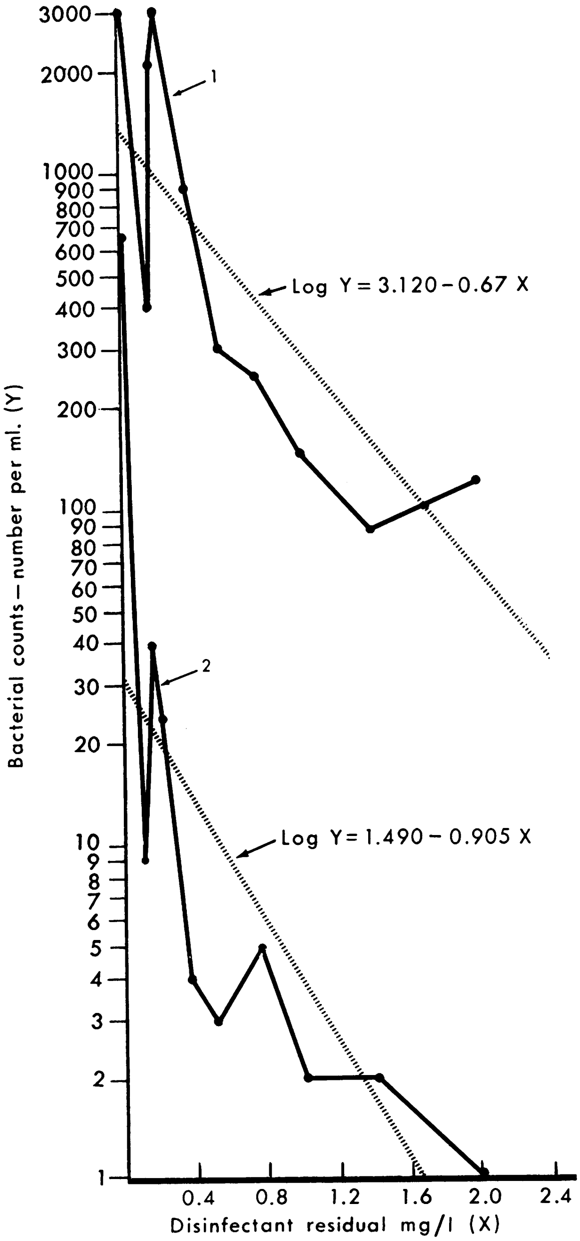
Of 679 disinfectant residual tests, the mean residual from pool waters, excluding wading pools, was 0.84 mg./l. with a standard deviation of 0.52 mg./l. Roughly two-thirds of the sample results lay between 0.35 mg./l. and 1.4 mg./l., indicating that the pools were operating within reasonably close proximity to recommended concentrations of disinfectant.

Of 353 pH tests, excluding wading pools, the mean pH was 7.29 with a standard deviation of 0.28. About two-thirds of the sample results indicated a pH between 7.0 and 7.6, again indicating that the pools were operating within the recommended pH.

That disinfectant residual readings taken on standard colorimetric field comparators built for this purpose do not always yield precise or even highly accurate results is well known. Continuous use of a pool results in an increase in the relative amounts of combined chlorine, the effects of which in a colorimetric testing kit can be eliminated only by reducing the temperature of the sample to about 40° F. and taking the reading quickly. Therefore, the aides were instructed to read the results as quickly as possible and to never allow the color to develop beyond 5 to 10 seconds. Color comparators, of course, are subject to fading. However, our kits were standardized with known solutions at the Chicago laboratories and they showed no difference when compared with new testing kits. We were not so concerned with whether or not the residual readings were highly accurate as we were with attempting to answer the pool operator's question: "What residual, according to my testing kit, must I maintain in the pool water in order to have a safe sample?"

The results of bacteriological analyses are plotted against disinfectant residuals in figure 3. Since the primary function of chlorine or bromine in pool waters is disinfection, we would expect that as the residual indicated on the colorimetric chlorine residual testing kits increases, the bacterial counts will decrease, and this appears to be the case as shown in the figure. The top set of data represent the locus of experimental points below which 90 percent of the bacterial counts fall for a given disinfectant residual. Plotting this data on semilog paper and using a least squares analysis, a

Figure 3. Results of bacteriological analyses of disinfectant residuals from swimming pools, Du Page County, Ill.



[1] The locus of experimental points below which 90 percent of the bacterial counts fall for the corresponding disinfectant residual.

[2] The locus of experimental points below which 50 percent of the bacterial counts fall for the corresponding disinfectant residual.

straight-line function is developed which is described by the following formula:

$$\log C = 3.120 - 0.67\ R \qquad [1]$$

where R = disinfectant residual as indicated on the standard Wallace and Tiernan chlorine testing kit, in mg./l., and
C = mean bacterial count per ml. as indicated by standard laboratory techniques.

A similar plot of experimental points, also shown in figure 3, is the locus of points below which 50 percent of the bacterial counts fall for the corresponding disinfectant residual. A similar analytical approach as used in formula 1 yields the straight-line function whose formula is:

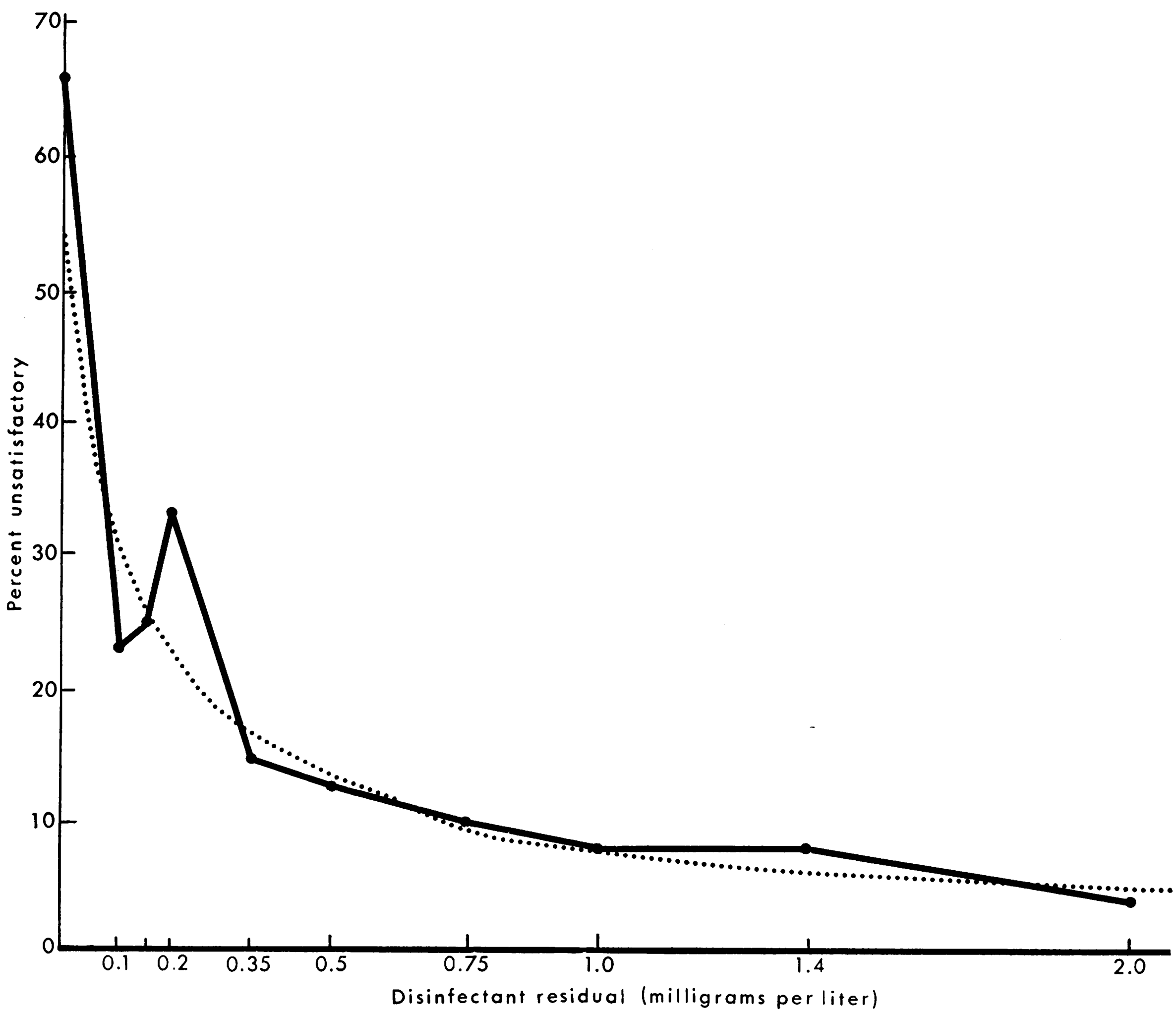
$$\log C = 1.490 - 0.905\ R \qquad [2]$$

where R and C are as defined in formula 1.

Generally we may conclude from these analyses that 90 percent of bacterial samples collected from swimming pools will meet State health department requirements (not more than 200 bacteria per milliliter) when the disinfectant residual is maintained at or above 1.2 mg./l.

The percentage of bacterial samples with unsatisfactory counts (greater than 200/ml.) for

Figure 4. Percentage of bacterial samples with unsatisfactory counts (greater than 200/ml.) for each disinfectant residual from swimming pools, Du Page County, Ill.



each disinfectant residual are shown in figure 4. With no residual, more than two-thirds of the samples were unsatisfactory, while at a residual of 2.0 mg./l., less than 4 percent failed. Between 0.5 mg./l. and the recommended 1.0 mg./l., unsatisfactory samples averaged about 10 percent. Casual inspection indicates what appears to be a "breakpoint" at approximately 0.35 to 0.5 mg./l., below which the percentage of unsatisfactory samples increases rapidly. It would seem that 0.5 mg./l. is a disinfectant residual below which no pool can be safely operated. The dotted line is an "eye" curve and has not been calculated.

With no disinfectant residual, less than 10 percent of the samples had zero bacterial counts; yet when the residual increased to 2.0 mg./l. almost half of the samples were bacteria free. Generally, a plateau seemed to exist between 0.5 and 1.4 mg./l. where the zero count percentage averaged about 33.

The average bacterial counts shown below related to the clarity of the water (rated visually by the engineering aide) at the time of sampling:

Clarity rating	*Number of samples*	*Average count/ml.*
0	4	575
1	20	1,066
2	44	60
3	384	229
4	388	101

It would appear that there were not enough samples to give a reliable count where clarities were recorded as 0, 1, and 2. Perhaps quantitative measurements of turbidity are required to establish a relationship between clarity of water and bacterial counts.

Pool Ratings

One of the most interesting aspects of our pool program is the comparison between pool rating scores and operating conditions as reported by our engineering aides. In figure 5 the operation score on the 1963 pool rating form has been plotted against the percentage of unsatisfactory bacteria samples for each pool. Generally, as the samples become progressively worse, the operation score is reduced in accordance with the following equation:

$$O=20.0-0.135\ P \qquad [3]$$

where O=operation score on the 1963 pool rating form

and P=percentage of bacterial samples with counts greater than 200/ml.

We have also noted a change in the total pool rating scores in the past 3 years, which we feel is a direct result of the quantitative method of handling and processing data made possible during that period. As shown below, both the mean and the median total pool ratings have decreased.

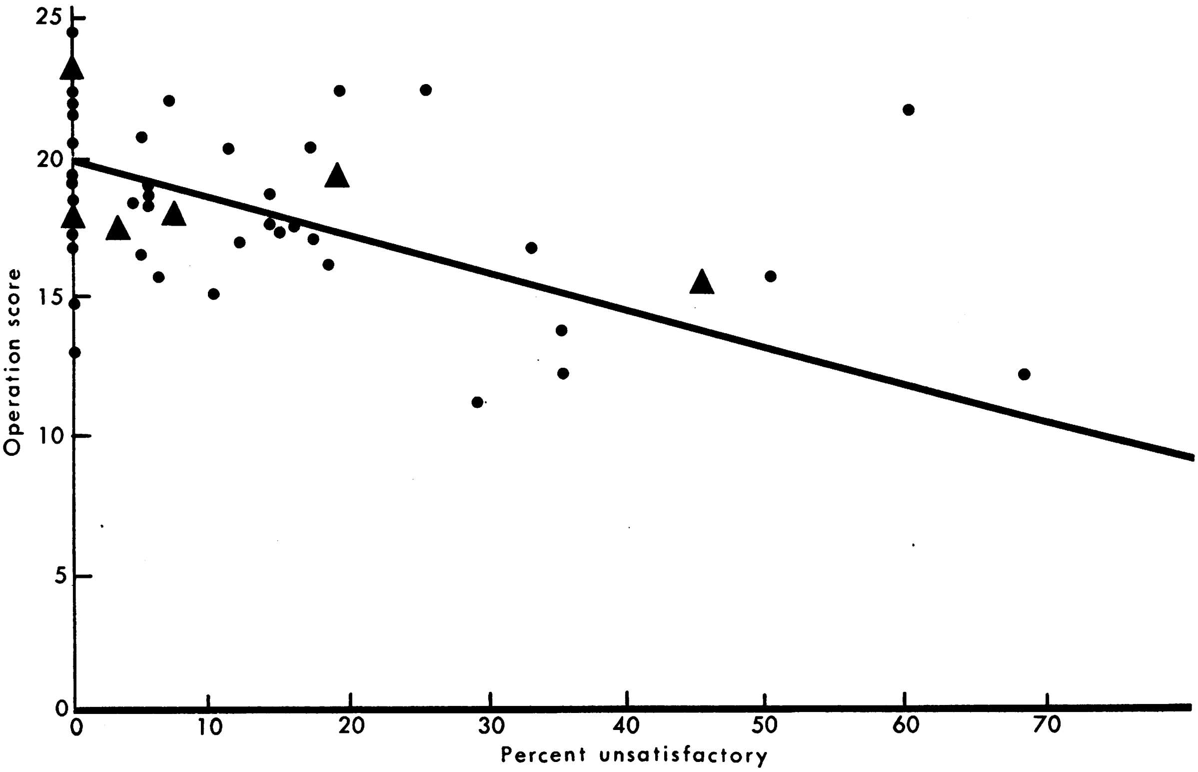
Year	*Mean pool rating*	*Median pool rating*
1961	93.5	95.0
1962	89.4	90.8
1963	87.1	87.7

This decrease at present is due almost entirely to a general reduction in operation scores. We expect that these ratings will level off as we perfect the system for calculation of operation scores. We hope that a similar rating system can be developed to cover other aspects on the total pool rating form which are not narrowly defined as "operational."

The quantitative approach to pool operation rating has resulted in a marked reduction in the percentage of class AA pools and has tended to produce an approximately normal distribution where a large number of pools can be classified as A and B, a smaller number as AA, and a few as class C. Although there are no class D pools in the county, 11 of the pools had less than 65 percent of the maximum number of points available under the heading "operation," and would thus fail to meet public pool standards if such pools were rated entirely on operation.

The relationship between pool volume and pool classification scores is shown in figure 6. Each point represents a group of five pools arranged by size: the first point (farthest left on the graph) represents the average volume of the five smallest pools in the county and is plotted against the average percentage of operation score and the average total score of these five pools. As pool volumes increase both scores increase. Larger pools have both better facilities and better operation, and there is a greater difference between total capability and operational capability among smaller pools than

Figure 5. Percentage of unsatisfactory bacterial samples from swimming pools according to operation scores on 1963 rating form, Du Page County, Ill.



among larger pools. Possibly an improved method of rating the three sections on the pool rating form, exclusive of the operation section, will result in some change in the slope and Y intercept of the overall rating curve.

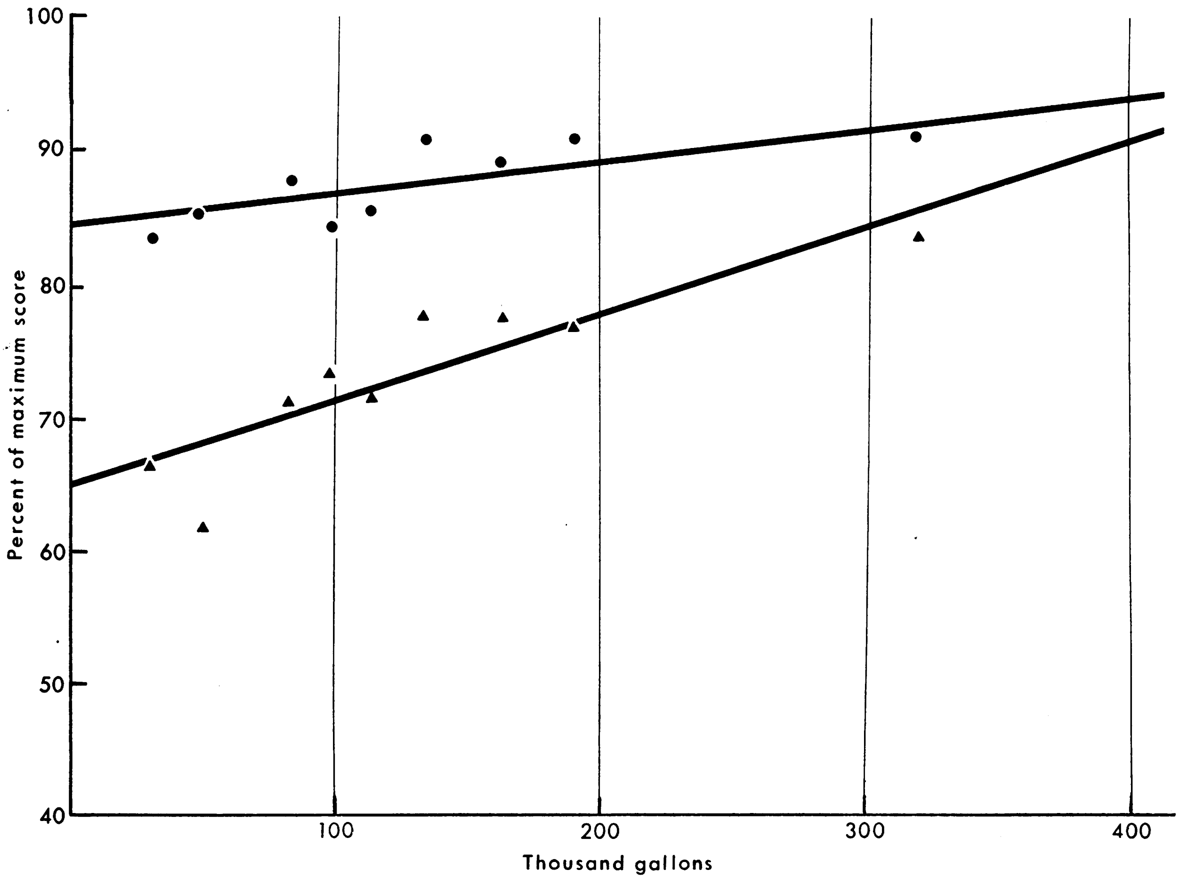
Conclusions

The data handling and processing system has allowed us to better evaluate the operation of public swimming pools. With the simple tabulation of data we can quickly and easily pinpoint problems at a given pool. The data are presented on two single sheets of coded information. The pool operations can be rated entirely quantitatively, based on the engineering aide's observations. In extenuating circumstances the engineer, of course, makes the final judgment. However, no such circumstance has as yet arisen.

There are several requisites to a successful pool program such as ours. Some type of routine inspection program must be established. We feel that visits should be made at least once a week. While this has not brought our worst pools up to satisfactory standards, the great majority have been given sufficient impetus to maintain excellent swimming facilities for the residents of the county. We feel that with the large amount of data necessarily collected by such frequent visits, some type of automatic data handling and processing system is necessary to assimilate and record such data quickly and accurately. Our system has performed this useful service at a nominal cost, and we encourage other agencies to adopt similar programs.

In addition to these general conclusions, we believe that our results have clearly shown that disinfectant residuals must be maintained at 0.5 mg./l. or above in order to achieve satisfactory destruction of bacteria for swimmer protection. To be 90 percent sure of a satisfactory sample, the residual must be increased to 1.2 mg./l. With proper pH control, residuals of this magnitude will be tolerated by almost all swimmers. Larger pools apparently have better facilities and better operation than smaller pools. Gas-chlorinated pools, partly because they are larger pools, seem to be linked with

Figure 6. Relationship between swimming pool volumes and classification scores, Du Page County, Ill.



lower bacterial counts and fewer unsatisfactory coliform and streptococcal samples. The percentage of unsatisfactory bacterial samples also seems to be associated with a lower operation score as calculated from visits by our engineering aides.

Pool ratings have tended to decrease in the past 3 years, although the distribution of pool letter scores has tended toward a normal distribution. Eleven pools failed to achieve 65 percent of the maximum number of points available for operation. Before the program was developed there was a tendency to overrate a pool (to give it the benefit of a doubt during annual inspection), a tendency which probably exists in pool inspection programs of other agencies. While one student was ordinarily able to sample approximately 25 pools per week, we feel that a change in his working hours may allow him to sample twice that number. With the aide working Monday through Friday, only the first 4 days each week were available for collecting samples. In addition, few pools opened until early afternoon, allowing only 4 to 5 hours for sample collection. This year our pool aide worked from about noon to 8 or 9 p.m. Sunday through Thursday. We were thus able to get 5 full sampling days of 7 to 8 hours per day.

Following are recommendations for the improvement of the swimming pool program based on the findings.

1. Some method should be devised to equate the pool ratings directly with the occurrence of unsatisfactory samples. At present we can only deduct points for lack of disinfectant residual, poor water clarity and bather inspection, and unsanitary dressing rooms, pool and spectator areas, and toilets and lavatories.

2. A quantitative method of evaluation should be devised for those aspects not narrowly defined as "operation." This method should man-

ifest itself in lower ratings in other sections of the pool rating form when applicable.

3. Pool filtration rate data should be collected at each visit to the pool to determine to what extent this relates to bacterial quality.

4. Quantitative turbidity measurements should be made to determine to what extent turbid water is associated with poor bacterial samples.

5. The rapidly growing population and the large numbers of new pools being built will require an educational program for pool operators, perhaps ultimately resulting in certification by local or State agencies.

NOTE: Copies of all the forms mentioned in the paper are available from the Du Page County Health Department. They may be reproduced without permission.

Removing Radioactive Material From Milk

The pilot plant of a transportable system for removal of radioactive fallout materials of health significance from milk is being constructed under a contract supported by the U.S. Department of Health, Education, and Welfare and the U.S. Department of Agriculture.

The contract, for $141,472, was awarded to the Chemical Separation Corp. of Oak Ridge, Tenn., in June 1964. It calls for design and fabrication of a pilot system that can be transported in a semitrailer truck and used with regularly operating milk equipment, producing about 800 pounds of treated milk per hour.

The equipment is being designed to process milk through the double-loop anion-cation exchange. Preliminary tests have indicated that the process can remove a major portion of strontium 90, cesium 137, iodine 131, and other radioactive contaminants from fluid milk without detectable loss of flavor or significant reduction in nutritional value. Upon completion, the pilot system will be transported to the Public Health Service Southeastern Radiological Health Laboratory at Montgomery, Ala., for further testing and developmental work.

Another process, the fixed-bed ion-exchange system, developed by the Department of Health, Education, and Welfare, Department of Agriculture, and the Atomic Energy Commission to remove radioactive strontium and cesium from fluid milk, is being evaluated for commercial feasibility at the Lebanon plant of Producers Creamery Co., of Springfield, Mo., under a contract supported jointly by DHEW and USDA. It is a full-scale fixed bed system handling 100,000 pounds of milk in an 8-hour period. Tests have shown that more than 90 percent of the radioactive strontium can be removed by this process.

Both systems have been developed as methods to be considered in the event of nuclear emergency. Officials explained that present and foreseeable consumption of radioactive materials in milk and other food is well below the level considered by the Federal Radiation Council to be an acceptable daily intake. The "acceptable daily intake" is for a lifetime under normal peacetime conditions compatible with the orderly development of the nuclear industry of the United States.

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