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A water quality survey

DALE E. MCMICHAEL *

ABSTRACT — Representative factors influencing water quality in the Albert Lea, Minnesota area were chosen as to assess water quality and changes in the watershed which has been described as an earlier valley of the Shell Rock River.

Parameters representative of chemical, bacterial, and thermal pollution were, respectively, total phosphorous, total and fecal coliform counts, and temperature. Statistical analysis has revealed that significant differences in some parameters measured do exist when various sampling stations of a given sampling date are compared. Statistical analysis also has indicated that correlations do exist between fluctuation patterns when all sampling stations of a given sampling date are examined. Correlations between parameters and their fluctuation patterns were relatively low.

In recent years, attention has been focused on various indicators of water pollution. The existence of a multitude of parameters to detect and measure water quality has led to confusion as to measuring methods when a board spectrum analysis is not possible. The need has arisen for a simplified survey technique by which a few of the more important parameters may be detected, measured, and evaluated for indications of general water quality. A more sophisticated form of this type of survey has provided much useful information, but it involves very technical chemical measurements and complex mathematical indices of pollution and water quality (Shoji, et al., 1965).

This suggested water quality survey includes a single chemical parameter; total phosphorous. Total phosphorous was chosen because it is considered to be an important element essential to the growth of algae. Algae is important because of its effect on the rate of eutrophication or aging of a lake. P. L. McCarty, chairman of the Water Quality Division Committee on Nutrients in Water (1970), has reported that half of the surface waters in the United States have had treatment problems due to the excessive growth of algae and other aquatic plants. Nitrogen, as well as phosphorous, is recognized as an important factor in algae growth, however, the Minnesota Pollution Control Agency (1970), recognizes phosphorous as being the more crucial factor. Edmonson (1970), has demonstrated the importance of phosphorous as related to algae in a lake system. Odum (1969) considers total phosphorus more meaningful than analysis of the various forms of phosphorous. Rather simplified methods for total phosphorous analysis in water or waste water have been suggested by Frazier (1970).

This suggested water quality includes total and fecal coliform counts as the bacterial parameter. Coliform bacteria were chosen as a parameter because they are considered to indicate sewage pollution and are believed to indicate the possible presence of potentially dangerous pathogens (Pelzar & Reid, 1965). The *Escherichia* coli and *Aerobacter aerogenes* type coliform organisms represent the two main types of coliforms. Because E. coli is considered to be primarily of intestinal origin whereas A. aerogenes is considered to be primarily and commonly of plant and soil origin, methods for distinguishing the two types have been developed (Pelzar & Reid, 1965).

Harmful bacteria and coliforms, especially fecal coliforms of the E. coli type, generally occupy similar or the same habitat. The coliforms are much easier to detect than the pathogens that might reside with them and are therefore used as indicator organisms of pathogens. Total coliform counts are widely used for public health standards involving water quality.

This survey plan includes temperature as a parameter indicative of thermal pollution. Because temperature is a prime regulator of natural processes within the water environment, it is considered to be of prime importance as a parameter (U.S.D.I., 1969). Temperature determines which aquatic species may be present; it controls spawning and hatching, regulates their activity, and stimulates or depresses their growth and development. Temperature can attract or kill when the water becomes heated or chilled too suddenly. Colder water generally suppresses development; warmer water generally accelerates activity (U.S.D.I., 1969). Temperature and related altitude studies have shown such tendencies to have occurred (Nebeker, 1971).

Sampling Stations and Intervals

In establishing the water quality survey, sampling stations were designated and weekly samples taken at each from June to September, 1970. Twelve stations were established so as to yield data from which representative fluctuations within the watershed could be readily assessed. The Shell Rock River valley watershed includes lakes, streams, and rivers. The predominant lakes involved are White Lake, Pickerel Lake, Fountain Lake, and Albert Lea Lake. The predominant streams are Bancroft Creek, Wedge Creek, White Lake Creek, Pickerel Lake Creek, and Fountain Lake Creek, which connects Fountain Lake to Albert Lea Lake. The predominant area river is the Shell Rock River. Other surveys have used the same number of sampling stations in a river system and have suggested that certain correlations exist between many of the parameters measured (Shoji et al., 1966).

All samples were collected in 100 ml. glass bottles with rubber stoppers. Samples of epilimnion water were taken by a rope and bucket sampler. The sampler was flushed twice in the water to be sampled prior to collection of the actual material for analysis. Samples were stored in a portable chest cooler until analysis was made

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at the laboratory. The state-certified Health Department laboratory of the City of Albert Lea, Minnesota, was the site of eventual sample analysis.

Total phosphorous was determined by the "highly sensitive" ammonium molybdate procedure (Frazier, 1970), with stannous chloride the reducing agent and potassium per sulfate the oxidizing agent. The Bausch and Lomb Spectronic 20 spectrophotometer set at 650 mμ was used for colorimetric analysis.

Coliform bacteria counts were determined by the Millipore Membrane Filter Technique. Specialized media were employed to differentiate fecal from non-fecal coliforms. Characteristic colonies were distinguished by blue and gray coloring. Dilutions of 1:100 were used. The range of counts was from 100 coliforms per 100 ml. of sample to 10,000 coliforms per 100 ml. of sample. Larger counts could be detected with the 1:100 dilution but were not encountered. Counts below 100 coliforms per 100 ml. of sample were not specifically determinable with the 1:100 dilution. Blank plates were recorded as "less than 100 coliforms per 100 ml. of sample." Counts below 100 coliforms per 100 ml. of sample are not considered to be dangerous by most public health standards. The standards usually refer to coliform counts and not to fecal coliform counts. The U.S. Public Health Service has recognized the Millipore Technique as a reliable method for the detection of coliforms in water. Standard Methods (1965) does suggest that when the Millipore method is used that it be substantiated by some other acceptable method. In this survey MPN, or most probable number, was used to substantiate the Millipore method.

Temperature was measured immediately upon collection of the sample at the sampling site with a standard Fahrenheit thermometer having the smallest scale divisions of 0.1° F.

The data were tested using a statistical sequence and a Two-Way Anova Without Replication (Sokal & Rohlf, 1969). This test did not indicate where significant differences occurred but did indicate a need for more refined and specific analysis if any existed. Individual times or sampling dates were analyzed by the Pearson Product Moment "r" Correlation Coefficient test (Sokal & Rohlf, 1969). This test was used to indicate if fluctuation patterns of and within a single parameter were or were not constant in time. Individual parameters were analyzed by the Student's "t" test (Steele & Torrie, 1960). This would reveal differences between locations using data from all dates at a location compared with data from all dates at another location. Finally, the Pearson Product Moment "r" Correlation Coefficient test (Sokal & Rohlf, 1969) was used to see if correlations existed between the fluctuation patterns of entire parameters tested. Analyses were performed using a Univac 1106 computer with Fortran language.

Differences and similarities observed

Analysis of the total phosphorous data revealed that the total phosphorous fluctuation patterns within the watershed do not vary appreciably from one date to another. Significant differences do exist, however, between sampling stations. A general observation would be that stations 1-7 differ significantly from stations 8-12 in phosphorous concentrations. Also, station 1 differs significantly from stations 2-5 in concentrations of total phosphorous.

Analysis of the total coloform count data revealed that fluctuation patterns are similar and dissimilar in an equal number of cases each; however, significant differences in total coliform counts are found between station 7 and stations 1-6. Significant differences were found between station 8 and stations 9-12.

Analysis of the fecal coliform count data revealed that generally fluctuation patterns of fecal coliforms vary greatly when times are correlated. Analysis of the fecal coliform data also revealed that stations 4, 5, 7, and 8 show significantly different values.

Analysis of the temperature data revealed that fluctuation patterns are generally quite consistent and stable in time. This analysis also revealed that no significant differences exist between locations.

Correlations between parameters are low. The highest correlation of fluctual patterns was found between total phosphorous and temperature. Other correlations, arranged in decreasing order of magnitude of correlation, are total phosphorous and fecal coliforms, total phosphorous and total coliforms, and total coliforms and fecal coliforms having the lowest correlation coefficient.

Findings reveal variances

The total phosphorous data are quite stable with respect to variability of fluctuation patterns in time (i.e.): increases and decreases of total phosphorous in the watershed are constant in time. The "t" values indicate that there is a source of phosphorous somewhere between stations 7 and 8 or at either of them. This source has an influence which lasts for the remainder of the area surveyed. The municipal treatment plant is in this area, and it is in this vicinity that the greatest source of chemical pollution was found. Station 1 has much lower concentrations of phosphorous than all others in the watershed except for station 6. Sampling station 1 is the northernmost station and is in an extreme upstream location. Station 6 is the Fountain Lake Dam located at the end of Fountain Lake. Phosphorus consumption by the lake could easily account for low concentrations at station 6.

The total coliform count data show that entrance of coliforms into the watershed is not constant or stable in time. Natural runoff from sporatic rain would be a plausible explanation for this lack of consistency. The data indicate that somewhere between stations 6 and 7 there is a substantial source of coliforms. Several industrial or domestic sources or a combination of both would explain this occurrence. The significant differences found between station 8 and stations 9-12 is explained by the chlorination of the effluent at the municipal sewage treatment plant which is station 8.

Fecal coliform data show, as do the total coliform data, that entrance of fecal coliforms into the watershed is not constant or stable in time. In this case, runoff from the surrounding land is not a plausible explanation for such an occurrence. Sporatic changes in industrial or domestic sewage effluents is a more acceptable explanation of the data. Stations 4, 5, and 7 show significantly high levels of fecal coliforms when compared with all other sampling stations in the watershed. Stations 5 and 7 are especially high, and these are at areas in the watershed where sewage effluents are the greatest threat to public health. These stations are the Pickerel Lake Creek sampling station (5) and the Milwaukee R.R. Bridge (7) sampling station which is located at the end of Fountain Lake Creek or the "channel" area. Station 7, which had the record high fecal coliform counts, is located in a heavily industrialized area along the watershed.

Temperature fluctuations do not vary greatly in time or location. Thermal pollution does not seem to be a great and persisting problem in the area studied. Isolated cases of thermal pollution may, however, exist.

There is a positive correlation between total phosphorous data and temperature data. The slow-moving lakes would be expected to have slightly higher temperatures in their epilimnion waters and, also, there would be expected to be more aquatic organisms having uptakes of phosphorous far in excess of their need. Many explanations are possible for this correlation. The extremely low correlation between total coliform counts and fecal coliform counts suggests that total coliform counts are not necessarily the best indicator for the presence of fecal coliforms or for indicating the possible presence of potentially dangerous pathogens. This also has been pointed out and substantiated by other surveys (Siemer, 1968). Evidently, a revision is needed in the standards which are written in terms of total coliforms per 100 ml. of sample.

This simplified water quality survey has revealed the presence or absence of gross chemical, bacterial, and thermal pollution in the watershed of the Shell Rock River valley. This survey has the capabilities of narrowing down problem areas and also indicating the general nature of the pollution problem involved. This survey is especially good for it initially seeks out the greatest problem areas and is feasible when larger, more sophisticated surveys and analysis are not possible. This survey is by no means an end in itself because it does not delineate specific sources of pollution, however, it does delineate general areas which contain sources of gross pollution. This survey enables a concentrated effort to be directed at the more serious pollution problems in a water system. After this preliminary investigation is performed, a more detailed study can be applied efficiently to the water system being investigated.

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