# A CONTAMINATION STUDY OF THE CUMBERLAND RIVER FROM CHEATHAM LOCK AND DAM TO CLARKSVILLE MUNICIPAL WATER INTAKE

BY

WINIFRED HARMON RICKERT

# A CONTAMINATION STUDY OF THE CUMBERLAND RIVER FROM CHEATHAM LOCK AND DAM TO CLARKSVILLE MUNICIPAL WATER INTAKE

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A Research Paper

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Master of Arts

in Education

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by

Winifred Harmon Rickert

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To the Graduate Committee:

I am submitting herewith a research paper written by Winifred Harmon Rickert entitled "A Contamination Study of the Cumberland River from Cheatham Lock and Dam to Clarksville Municipal Water Intake." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Arts in Education, with a major in Biology.

Haskell C. Phillips
Major Professor

Accepted for the Committee:

Wayne E. Stamper
Dean of Graduate School

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# CHAPTER I

## INTRODUCTION

Within the last few years there has been a growing concern over the pollution of the earth. Individuals, civic organizations, schools, and local, state, and national government have sponsored programs to educate the people to the potential dangers of continuing pollution at the present rate.

In the 19th century, water seemed an ideal way of removing wastes from populated areas. Today, the sewage disposal plant of one city has become the drinking water supply of another city downstream. Many of our larger cities have inadequate disposal or sewage treatment plants. Many areas have improperly constructed storm sewers which during rainy seasons cause raw sewage to back up into homes, to overflow the land, and to be carried directly into streams and rivers.

Biologists have been concerned with the effects of stream pollution for many years. Surveys of the Illinois River by the Illinois Natural History Survey from 1913 to 1928 describe changes in the bottom fauna of the river due to sewage pollution. The Federal Government began action in 1956 with the Federal Water Pollution Control Act. The Water Quality Act of 1965 and the Clean Water Restoration Act of 1966 were attempts by the federal government to set standards and codes of operations to be administered through the Federal Water Pollution Control Administration. The federal government supplies almost half the cost of constructing and running sewage treatment plants in areas that comply with their standards. The fiscal budget for 1970 recommended $478.5 million for water pollution control activities and research in environmental health science.

Chemicals from industrial plants are the most difficult pollutants to detect and remove from water. Most are non-biodegradable and over a period of years build up to a toxic level in solution in the water or in the animal life. Reported mercury pollution of the lakes and rivers in recent weeks has startled the general public.

Even though most water contaminated only with sewage can be made potable by filtration and chlorination, there is still the danger of the destruction of fish and wild life, the transmission of disease to people engaged in water contact sports, and the evolution of the rivers from beautiful flowing bodies of water to sediment filled, foul smelling sewers.

# CHAPTER II

## DESCRIPTION OF STUDY

Clarksville, Tennessee (pop. 35,000) is located on the Cumberland River in Montgomery County. The average daily municipal water consumption of approximately five million gallons is taken from the river (mile 132.8). The water intake point is located approximately 57 miles downstream from the main sewage disposal plant of Nashville (pop. 180,000). This plant dumps daily about 50 million gallons of waste into the river. Additional pollution is added to the flow from numerous industrial plants located on the river in the Nashville area and by the communities of Bordeaux, West Nashville, Doziers, Gravelott, Lillamay, Sulphur Springs, and Ashland City.

The State Stream Pollution Control Commission and the Corp of Engineers have stated that the river purifies itself before it reaches Clarksville. Because the river slows down as it passes through Cheatham Lock and Dam it was felt that the organic material was oxidized. There are no thickly populated areas located on the river between Cheatham Lock and Dam (mile 148.7) and Clarksville intake (mile 132.8).

A study by Davis et al. (1968) reported a coliform count ranging from 6800 to 14,000 per 100 ml. one-third mile below the Clarksville intake.

The purpose of this study was to determine whether the high coliform count in Clarksville was due to local pollution from frequent overflow of the sewage line at the lift station located about two miles upstream or whether it was due to pollution carried from the area above the Cheatham Lock and Dam.

Four sampling stations on the Cumberland River were selected. Station 1 was located one-fourth mile above Cheatham Dam, station 2, approximately one-eighth mile below Cheatham Dam at the boat launch ramp, station 3, approximately three miles above Clarksville intake, and station 4, one-third mile below the Clarksville intake. Water samples were collected from these four stations at weekly intervals from May 6 to June 17, 1970.

# CHAPTER III

## METHODS AND MATERIALS

Top samples at a depth of about one foot were collected at the four sampling stations. The samples were maintained at the approximate temperature of collection during transportation to the laboratory. The time between collecting and culturing was never more than two hours.

The micropore filter technique, as described in the 12th Ed. of Standard Methods for the Examination of Water and Waste Water (1965), was used. This method was approved in 1962 and is used extensively by state and municipal laboratories (Geldreich, 1967). If the tests are performed properly the results are more precise and obtained more rapidly than the Multiple-Tube Fermentation Technique. This micropore technique is suitable for all water samples that do not involve extremely turbid water or water with a high number of background organisms. No successful method has been found to remove the turbidity without removing coliform organisms (Geldreich, Jeter, & Winter, 1967). Most surface turbidity, however, is associated with a high degree of pollution so that in making the proper dilution to obtain a satisfactory number of colonies the turbidity will usually be diluted out.

An attempt was made to avoid the common laboratory errors pointed out by Geldreich et al. (1967). A 150 ml. sample of water was collected in a 175 ml. collection bottle. This allowed ample room for mixing the sample before measuring an aliquot for filtration. The culture media were prepared immediately before use and care was taken to prevent overheating. Pre-sterilized Millipore (Type HA 0.45 u. pore size) grid marked filters were used with the Millipore filter holder.

Two filtrate volumes were used for every test. A preliminary sampling run was made to determine the most favorable amounts of water to use for each test. In the total coliform test 0.1 ml. and 1 ml. samples were used. Ten ml. of buffered distilled water were added to the filter before these small aliquots were filtered in order to insure uniform distribution of the colonies. The filters were rinsed with 50 ml. of the buffered distilled water. The discs were then incubated 18 to 24 hours at 35-37$^{o}$ C. in plastic petri dishes (52 mm. dia.) containing a sterile absorbent pad saturated with 2.0 ml. of Difco m Endo MF broth. This is a differentially selective medium that uses lactose as a source of energy and eosin as an inhibitory agent. Adequate humidity is needed to prevent drying of the plates.

The ideal plate for counting contained 20-80 colonies. The count was made using a 10X binocular dissecting microscope with the light adjusted to 60-80° above the colonies. All of the characteristic metallic-sheen colonies were considered coliform.

For the enterococcus determination 10 ml. and 100 ml. samples were used. The filter disc was placed on the surface of Difco m Enterococcus Agar, inverted, and incubated at 35-37° C. for 48 hours. Sodium azide in the medium inhibited non-enterococcus organisms and tri-phenyltetrazolium differentiated the colonies. All pink to red colonies were considered enterococci. The plates were examined using a 10X binocular microscope (Millipore Corp., 1969).

CHAPTER IV

RESULTS

The total coliform and fecal streptococcus count per 100 ml. of water for the four collection stations during a two month period is shown in Tables 1 and 2.

The average total coliform count of the water from station 1 (0.25 miles above Cheatham Lock and Dam) was 14,633/100 ml. while the average count for station 2 (below Cheatham Lock and Dam) was 7,033/100 ml. This indicates that the aeration of the water from passing through the locks caused a 50% decrease in the total coliform count. The water as it reached the locks was so highly contaminated that even with a 50% decrease in the coliform count it would still be considered unfit for a source of domestic raw water (Tennessee Stream Pollution Control Board, 1966). The difference in the average coliform count of station 2 (7,033/100 ml.) and station 3 (8,066/100 ml.) was probably due to drainage of adjacent livestock pasture land along the river. The average count at station 4 ( one-third mile below the municipal intake) was 7,183/100 ml.

The average fecal streptococcus count for the stations was 1- 309/100 ml., 2- 201/100 ml., 3- 113/100 ml.

TABLE 1

Total Coliform per 100 Ml.

| Date | Station 1 | Station 2 | Station 3 | Station 4 |
|---|---|---|---|---|
| 5-6-70 | 11,900 | 11,500 | 9,200 | 10,100 |
| 5-13-70 | 8,500 | 10,900 | 10,400 | 12,000 |
| 5-27-70 | 9,700 | 7,400 | 2,500 | 3,000 |
| 6-3-70 | 5,700 | 4,400 | 4,600 | 3,900 |
| 6-11-70 | 15,000 | 4,100 | 8,700 | 7,200 |
| 6-17-70 | 37,000 | 10,600 | 13,000 | 6,900 |

TABLE 2

Fecal Streptococci per 100 Ml.

| Date | Station 1 | Station 2 | Station 3 | Station 4 |
|---|---|---|---|---|
| 5-6-70 | 200 | 774 | 140 | 80 |
| 5-13-70 | 330 | 210 | 255 | 285 |
| 5-27-70 | 150 | 80 | 84 | 59 |
| 6-3-70 | 75 | 12 | 7 | 80 |
| 6-11-70 | 320 | 63 | 102 | 77 |
| 6-17-70 | 780 | 66 | 90 | 55 |

and 4- 106/100 ml.

The Cumberland River from Nashville to Clarksville seems to be an example where additional sources of pollution enter the river environment before the receiving water has been able to assimilate the entire effects of an initial source. The zones of degradation and decomposition become so mixed that large reaches of the river fall into the decomposition zonal classification. New pollution continues to be added so that there is no zone of recovery (Federal Water Pollution Control Administration, 1970).

# CHAPTER V

# DISCUSSION

Coliform bacteria are normal inhabitants of the intestinal tract of man and other warm-blooded animals. Their presence in water is indicative of a potential public health hazard because of the possible presence of pathogenic enteric organisms.

A fecal streptococcus (enterococcus) is any streptococcus commonly found in significant numbers in the feces of man and other warm-blooded animals. Evidence indicates that fecal streptococci do not occur in pure water or virgin soil and that they do not multiply in water (Applied Biology Seminar Training Manual, 1969). If a high fecal streptococcus count is found along with a high coliform count it is indicative that the coliform count is from fecal origin.

When a municipal water supply is taken from a heavily contaminated river there is always the potential danger of disease outbreaks due to malfunction of the water treatment plant or by water contact sports. Outbreaks of Shigella dysentery, Salmonella gastroenteritis, hepatitis, and leptospirosis have been traced to contaminated water.

In a study of the Lake Michigan beaches and Ohio

River swimming areas, Geldreich (1970) found that when the total coliform count ranged from 2,300 to 2,700 per 100 ml. there was a significant increase in swimmer illness.

After a study of the Calumet River Area in 1966 by the Federal Water Pollution Control Administration, a technical committee recommended that water was satisfactory for swimming if the coliform count was from 1,000 to 5,000 and the fecal streptococci were less than 20 per 100 ml.

Forrest (1970) in a study of J. Percy Priest Reservoir and its tributaries found that the fecal coliform segment of the total coliform in the tributaries averaged 29.5%. Geldreich (1970) reported that fecal coliform isolated from rivers constitute approximately 32% of the total coliform. He further stated "safe recreational water should contain fecal coliform densities of less than 200 per 100 ml. . . . Field data from numerous fresh water pollution studies indicate a sharp increase in the frequency of Salmonella detection when fecal coliform densities are above 200 organisms per 100 ml."

The total coliform count from station 1 above the dam ranged from 5,700 to 37,000 per 100 ml. and the fecal streptococci count ranged from 75 to 780 per 100 ml. The three stations below the dam had total coliform counts that ranged from 2,500 to 13,000 per 100 ml. and fecal streptococci counts ranging from 7 to 774 per 100 ml.

By applying Geldreich's percentage of fecal coliform to total coliform (1970), it can be calculated that the fecal coliform count of the Cumberland River ranged from 750 to 11,000 per 100 ml.

The Tennessee Stream Pollution Control Board (1966) has set standards for water quality for different uses. Domestic raw water supplies should have less than 5000 coliform per 100 ml. of raw water. Water suitable for swimming and other contact sports should have less than 1000 per 100 ml. They also state that over 10 fecal streptococci per 100 ml. might indicate water of doubtful sanitary quality and greater than 100 per 100 ml. indicates a high degree of recent fecal pollution.

Standards are meaningless unless there are methods for enforcing restrictions that will make these standards realistic.

The Tennessee Stream Pollution Control Division has conducted extensive stream pollution surveys of Old Hickory Reservoir (1962), Duck River Basin (1964), Hatchie River Basin (1964), The Chattanooga Area (1965), and the Upper Cumberland River Basin (1965). Nashville is the second largest city in the state. There is a great need for a survey of the Cumberland River from Nashville through Barkley Lake. Millions of dollars have been spent to create a polluted recreational area. The sources of pollution must be pin-pointed and cities and industries made to realize their obligation to help improve the nation's water supply.

# CHAPTER VI

## SUMMARY

Total coliform and fecal streptococcus determinations were made at weekly intervals from four stations on the Cumberland River between one-fourth mile above Cheatham Lock and Dam to one-third mile below the Clarksville municipal intake from May 6 to June 17, 1970. The micropore filter technique as described in the 12th edition of Standard Methods for the Examination of Water and Waste Water (1965) was used. The average total coliform count above the dam was 14,633/100 ml. while all three stations below the dam were approximately 7,500/100 ml. The fecal streptococcus counts averaged from 309/100 ml. above the dam to 106/100 ml. near the Clarksville intake.

The water as it reached the locks and dam was so highly contaminated that even with a 50% reduction due to aeration, it retained a count that was higher than that approved by the Tennessee Stream Pollution Control Division for a source of domestic raw water.

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