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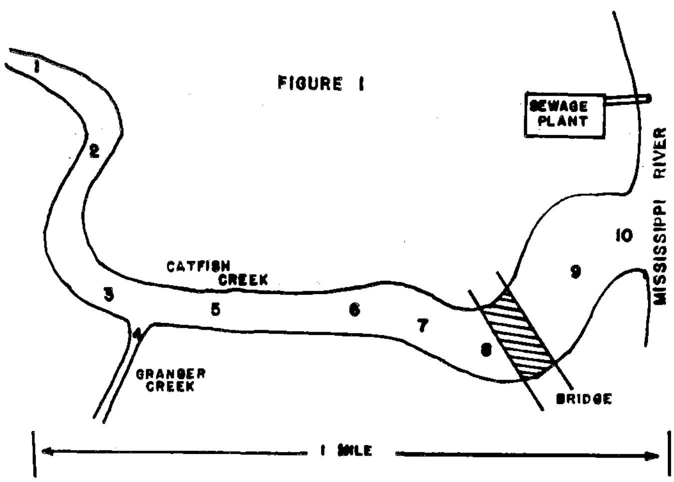
SYNOPSIS: A study of Fecal coliform distribution at the lower end of Catfish creek in Southern Dubuque County, Iowa was conducted from November 4 until December 30, 1970. The creek's mouth is approximately ¼ mile below the outflow pipe of the Dubuque wastewater treatment plant on the Mississippi River. The plant presently has only primary treatment, but a new plant is scheduled to begin operation soon. This and subsequent studies will show the actual effect on the surrounding environment of introducing secondary treatment to a primary wastewater treatment plant.

It was found that the contamination levels below the Dubuque wastewater treatment plant outflow pipe were high. In turn, backwaters of the Mississippi River carried this contamination about ¼ mile upstream into Catfish creek. The Mississippi River water level had a direct effect on the extent of pollution of Catfish creek upstream from the Mississippi River.

Catfish creek is a small, spring-fed stream originating 15 miles southwest of Dubuque, Iowa, in Dubuque County. The mouth of the creek empties into the Mississippi River approximately ¼ mile below the overflow pipe of the Dubuque wastewater treatment plant, which is an excellent site to sample Fecal coliforms. A new plant, located one mile further west, is scheduled to go into operation in March, 1971. After the new plant is operating, pollution in the Mississippi River should show a decrease in Fecal coliforms.

This study resulted from observations reported by Wojcik (1970), who found that the upper regions of Catfish creek were fairly uniform in total coliforms with less than 400 colonies per 100 ml reported at all sampling sites, but between one mile upstream and the mouth there was a tenfold increase. The purpose of this study was to reinvestigate the area in question and determine if Wojcik's data were accurate; and if so, where the additional pollution originated. Since Fecal coliforms are a better indication of actual pollution than total coliforms, the study was switched to Fecal coliforms (Geldreich, 1970).



Total coliform counts above Dubuque were first obtained from the Dubuque Water Treatment Plant located at lock and dam 11 to determine if Dubuque was contributing to the pollution of the Mississippi River and thus to Catfish creek. Samples were taken Nov. 4 - Dec. 30, 1970, inclusive. During this period of time six samplings, covering from 6 - 10 sites, were made. The first two dates were used to sample the last mile of the creek to determine if the coliform change was distributed evenly throughout this mile. The last four samplings were used to determine if a sharp change between polluted water and clean water existed, and if this did exist how the river level influenced the location of this change and the bacterial counts. Also, on the final dates, a station was sampled immediately below the outflow pipe of the sewage plant to obtain some indication of bacterial levels being released into the river.

LITERATURE REVIEW

The use of the presence of bacteria as an indicator of the sanitary quality of water began in 1880 when von Fritsh described *Klebsiella pneumoniae* and *K. rhinosclermatis* as characteristic organisms of human contamination (Clark et al., 1964). Shortly thereafter Escherich added his *Bacillus coli* as an additional indicator (cited by Geldreich, 1970). Eijkman (cited by Geldreich, 1970), in further work, divided the coliform group into a fecal group which produced gas from glucose at 46°C and a non-fecal group which produced no gas under similar conditions. Fecal coliforms are not the only indicators of pollution, but they are the easiest to sample and to date the most reliable of the indicator bacteria that have been used for such purposes. Some of the intestinal pathogens that might be present if Fecal coliforms are observed are *Salmonella, Shigella, Vibrio, Mycobacterium, Pasturella,* and *Leptospira* (Geldreich, 1965).

METHODS AND MATERIALS

The method used in collecting samples varied because of changing river conditions. An aluminum boat was used for the first four sampling dates. After sufficient ice was formed on the creek, the sampling was accomplished by using an ice auger to bore through the ice cover. Sterile bottles (150 ml) were immersed to a depth of 6 inches and rinsed four times before taking the sample. The bottles were filled about two thirds full so the samples could be mixed before bacterial counts were made. Sterilization was done by thoroughly scrubbing the bottles in a detergent solution, immersing in boiling water, and tightly recapping after they were dry. All of the samples were filtered within two hours of being taken.

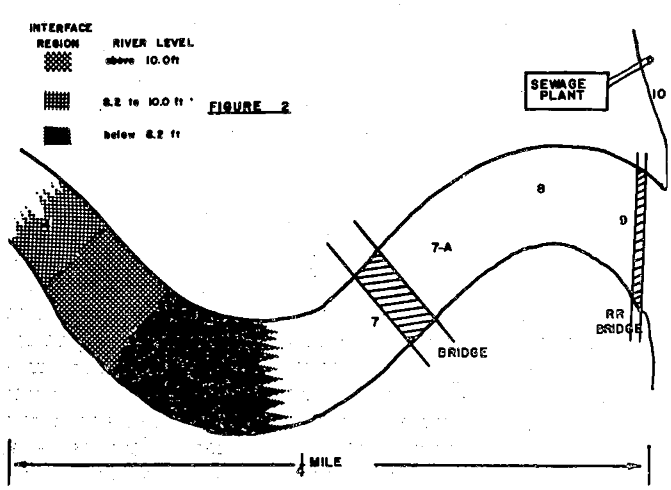
The desired quantity of water was measured into a beaker and diluted with distilled water to a volume of 50 ml. A control was run for each trial to determine if the apparatus was sterile. Filtration was accomplished by using the Sterifil Filtration System (Millipore Corporation). This consists of a 47 mm filter holder and a receiver flask. The filter used was the Millipore type HA white filter with a gridded surface. The pore size is 0.45μ which is sufficiently small to prevent passage of Fecal coliforms while allowing easy passage of water (Dennison, 1968). After filtering, the membrane filter was placed in a sterile plastic petri dish (Millipore Corporation) which contained an absorbent pad saturated with 2.0 ml of MFC medium (Baltimore Biological Laboratories). The petri dishes were then sealed in water proof plastic bags (Whirl Pak, a product of NASCO, Fort Atkinson, Wisconsin) and submerged in a water bath for 24 hours.

The water bath consisted of a five gallon glass aquarium in which a Constant Temperature Circulator (Bronwill Corporation) was placed to keep the temperature constant at 44.5°C (±0.5). After 24 hours the filters were removed from the petri dishes and placed on an absorbent pad to dry, and finally the colonies were counted. In most cases easy counting could be done unaided by the binocular microscope; however, in the few plates where the highest dilution still gave counts over 100 colonies per ml the binocular scope was used. Ideally numbers over 100 colonies per ml should be diluted to reduce the error.

The results from the first two collections were used to determine if the change noted by Wojcik (1970) was gradual from points 1 and 8 (Fig. 1), or if somewhere along the stretch there existed a point where a sharp increase occurred. From these two samplings, a vast increase in Fecal coliforms was observed between sites 6 and 8.

The final four samplings concentrated on the stretch of Catfish creek from and beyond sites 6 to 10 of Figure 1. These new sites were placed as shown in Figure 2.

In addition to the coliform counts, water temperature readings were taken before sampling began. After the study was completed, elevation readings were taken to determine if the fall of elevation from sampling points 4 to 9 (Fig. 2) had a significant bearing on the location of the area of sharp



change. River levels were obtained from the Dubuque Weather Service Office the date of each sampling. The three regions of Figure 2 were drawn to indicate the interface with respect to river levels.

RESULTS

Before the sampling of Catfish creek was begun, total coliform counts were obtained from the Dubuque Water Treatment Plant. The counts, obtained at Dam #11 above Dubuque, showed that the Mississippi River contained between 200 and 400 total coliforms per 100 ml of water.

TABLE 1. FECAL COLIFORM DENSITIES PER 100 ML FOR THE SIX SAMPLING DATES. THE LOCATION OF THE SITES IN THE FIRST TWO TRIALS ARE SHOWN IN FIGURE 1 AND THE SITES IN TRIALS THREE THROUGH SIX IN FIGURE 2.

SITE #	FECAL COLIFORMS per 100 ml	SITE #	FECAL COLIFORMS per 100 ml
First Trial 11-4-70 river level 10.3′		Second Trial 11-16-70 river level 10.4′	
1	0	1	95
2	200	2	480
3	100	3	250
4	0	4	20
5	100	5	35
6	400	6	30
7	7,000	7	9,600
8	2,500	8	25,000
9	43,000	9	21,000
10	54,000	10	62,000
Third Trial 12-2-70 river level 9.9′		Fourth Trial 12-10-70 river level 7.9′	
1*	25	1*	270
4	60	4	180
5	300	5	40
6	7,900	6	1,600
7	36,000	7	14,000
8	48,000	9	50,000
9	560,000	10	1,700,000
10	420,000		
Fifth Trial 12-16-70 river level 8.3′		Sixth Trial 12-22-70 river level 9.7′	
1*	820	1*	400
4	990	4	16,000
5	13,000	5	16,000
6	18,000	6	4,400
7	90,000	7	20,000
7-A	60,000	7-A	110,000
8	40,000	8	130,000
9	290,000	9	43,000
10	4,500,000	10	150,000

*See Figure 1

Table 1 shows the results of the first two collections in which the last mile of Catfish creek was sampled (Fig. 1). In these two trials a sharp increase in Fecal coliform densities occurred between sites 6 and 7. On November 4, the counts per 100 ml were 400 to 7000 and on November 16 the counts per 100 ml were 30 and 9600, respectively.

Table 1 also shows the results obtained for trials 3 through 6. In these trials the sites except site 1, were located as shown in Figure 2. Highest Fecal coliform densities were obtained at site 10. Lower coliform densities were obtained at sampling points up Catfish; noticeable decreases were observed especially between sampling sites 5 and 6 in trials three and four and sampling sites 4 and 5 in trial five. In the last trial, significant levels of Fecal coliforms were found even further upstream (Table 1).

DISCUSSION

From the results in Table 1 it can be seen that there is a definite region in Catfish creek where sharp differences in Fecal coliform counts are found. Counts are low upstream from this region and high downstream from this region. This region from now on will be termed the interface. When the coliform counts are plotted on logarithmic paper, the interface is that region in which a sharp change in the slope of the graph occurs.

There were four possible sources of the coliforms recovered from the river samples. One of these, contamination of the Mississippi from above the City of Dubuque, was ruled out by the data collected from the Dubuque Water Treatment Plant at Dam #11. The counts of 200 to 400 per 100 ml on Mississippi River samples obtained above Dubuque were insignificant compared to counts found in samples obtained below the interface of Catfish creek.

Two other possible sources of contamination were examined in Trials 1 and 2. The pasture land located next to sites 2 and 3 on Catfish creek and site 4 on Granger creek (Fig. 1) were found to add little additional pollution. In Trial 2, the Fecal coliform densities decreased downstream from these three sites until the interface was reached. Excluding these three sources of possible contamination, this study concentrated on the region below the sewage plant and the last ¼ mile of Catfish creek.

Problems with actual numbers obtained arise from the possibility that the organisms multiply after discharge from the sewage plant. *E. coli* can reproduce at temperatures as low as 20°C (Watson, 1965), but during most of the study the water temperature was well below this level, thus growth would be minimal.

As the study progressed, it was seen that the river level apparently had something to do with the location of the interface. All of the interface regions occurred within a 1/8 mile stretch between sites 4 and 6 (Fig. 2). As the river level of the Mississippi rose, the interface region retreated upstream. Most of the samplings were taken when the river level was between 8.0 feet and 10.0 feet. The interfaces of these trials were in a narrow band as shown in Figure 2.

These interface regions would be expected to retreat upstream as the quantity of backwater from the Mississippi River increased; thus, there should be a reason why they are located in small bands (Fig. 2). After the study was completed, elevation readings were taken on the premise that there might be a drop in elevation from points 4 to 7 (Fig. 2). The results indicated that the interface regions occurred where the elevation drop was no more than 3 inches, so that when the Mississippi River rose 2.5 feet, the interface rose less than 3 inches. It does not seem probable that the elevation of Catfish creek is meaningful in determining the interface. During most of study the area had an ice cover and thus the temperature differences cannot explain the location of the interfaces.

One possible explanation for the location of the interface between sites 4 and 7 may be the currents which exist in Catfish creek and the Mississippi River. Because of the ice cover, these currents were not determined. We believe the high coliform counts experienced in Catfish creek below the interface are due to the backwater from the Mississippi, but the reason for the exact location of the interface cannot be explained by this study.

All of the counts during the study were well above the limit of 1 per 100 ml for drinking water. In most cases, the creek was suitable for swimming above the interface and unfit below this region. This limit set for swimming is 200 Fecal coliforms per 100 ml (Geldreich, 1970).

The data indicate that the contamination released into the Mississippi River by the sewage plant probably has a direct effect on Fecal coliform levels in the lower extremity of Catfish creek. This backwater contamination is not evenly distributed throughout the creek but rather there exists a definite interface.

This study is an ideal starting point to discover the effectiveness of new sewage treatment methods. The new treatment plant was scheduled to go into operation in March, 1971. A marked decrease in the contamination of Catfish creek should have followed.

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