A REPORT FROM

# *The State Hygienic Laboratory*

MEDICAL LABORATORIES BUILDING

THE UNIVERSITY OF IOWA

IOWA CITY, IOWA 52240

# MISSISSIPPI RIVER WATER QUALITY
# SURVEY REPORT
# KEOKUK, IOWA AREA
# RIVER MILES 354.3 - 363.9
# #70-8

Submitted to the Iowa Water Pollution Control Commission
by the
State Hygienic Laboratory
September 28, 1969

# PREFACE

The Iowa Water Pollution Control Act states that pollution must be proven prior to action by the Iowa Water Pollution Control Commission. Pollution is defined as a condition whereby intended downstream uses are adversely affected and pollution is measured against the officially adopted Iowa Water Quality Standards.

This report delineates chemical, bacteriological and biological conditions measured from October, 1968 through September, 1969, and is the fifth of a series of evaluations as outlined May 12, 1969, to the Commission.

## INTRODUCTION

The Keokuk area is the last source of Iowa wastes as the Mississippi flows to the southwest, leaving Iowa and then bordering the states of Illinois and Missouri. Lock and dam 19 at Keokuk forms the downstream barrier for a pool 47 miles long which is the largest on the entire Upper Mississippi River. Between lock and dam 19 (mile 364.5) and the Des Moines River mouth (mile 361.4) exist approximately 3 miles of Iowa shoreline. The Des Moines River represents the border between Iowa and Missouri at this point.

Previous studies, conducted at Keokuk in October, 1968 and February, 1969, looked primarily at the chemistry and bacteriology of the river. These findings were reported to the Iowa Water Pollution Control Commission shortly after their completion and the results are included in Appendix A and B to this report. This report includes studies on the chemistry, bacteriology and biology of the river in the Keokuk area during the week beginning September 8, 1969. The river flow during this time was much lower than during the other two study periods in the Keokuk area. According to the U. S. Corps of Engineers the discharge rate at lock and dam 19 was 39,000 and 36,000 cfs respectively on September 8 and 9 when chemical and bacteriological sampling was being done. This compares to 55,300 - 63,500 cfs during the October, 1968 study and 54,400 - 62,400 cfs during the February, 1969 study.

## WASTE SOURCES

Known waste sources at Keokuk are Soap Creek, the Keokuk Municipal Sewage Plant outfall, the Hubbinger Company, and the outfalls from the industrial complex formed by Keokuk Electrometals Company (KEMCO) and Keokuk Steel Castings. The municipal water works at Keokuk is alleged to discharge waste sludge to the Mississippi above mile 363.6.

Soap Creek (erroneously called Bloody Run in previous reports) enters the Mississippi at mile 362.9 approximately 0.1 mile upstream from the Keokuk Municipal Sewage Plant outfall. In addition to other possible wastes, Soap Creek received intermittent discharges from the Hubbinger Company which is a large grain processing industry. In the October, 1968, survey, large quantities of waste were being discharged by Hubbinger into Soap Creek, however, from September 8-10, 1969, no significant wastes from Hubbinger were observed entering the creek. During the present survey there was a substantial flow from the Keokuk Waste Treatment Plant through Soap Creek. A check with the plant operator revealed that a lift station pump had broken and that the diversion of part of the raw sewage into Soap Creek was a temporary necessity until the pump was repaired. Ordinarily no discharge from the municipal plant occurs in Soap Creek.

The Keokuk Treatment Plant outfall is located at river mile 362.8. In addition to receiving the primary treated waste from the municipal plant, this outfall serves as a common sewer for raw wastes from the Hubbinger Company which is located nearby. The Hubbinger Company, a large grain processing industry, sends part of its waste through the municipal plant for primary treatment while the remainder is discharged directly to the river without treatment.

Keokuk Steel Castings and Keokuk Electrometals Company are side by side on the river bank between river mile 361.7 and 362.2. In this area there are numerous outfalls of various sizes, some of which discharge continuously and some intermittently.

The confluence of the Des Moines River (mile 361.4) is located a short distance downstream from this industrial area. Below the Des Moines River mouth, the Mississippi is bordered by Illinois and Missouri.

## METHODS OF STUDY

Chemical, bacteriological, and biological samples were collected upstream and downstream from the major waste discharges. As in previous studies, emphasis was placed on collecting samples along the Iowa bank since it had been established that wastes discharged from or near the bank tend to mix very slowly with the main flow of the river. Water samples were generally taken at mid-depth in shallow water or 6 - 8 feet below the surface in deeper water. Well downstream from waste outfalls, samples were taken at intervals across the river to determine to what extent the waste had diffused or mixed with the main river flow. Temperature and pH were measured in the field and dissolved oxygen samples were fixed in the field but titrated in the laboratory. All chemical and bacteriological samples were refrigerated after collection until analyses could be performed.

The biological study consisted of two phases; the first was to determine the types of invertebrate or fish food organisms inhabiting the river and to evaluate the effects of the waste discharges on them. This was accomplished by sampling with a Ponar Dredge, a heavy clam shell-like device which grabs a 9 inch square portion of the bottom sediment. This dredge sample was then sifted through a 30 mesh wire screen to separate resident organisms from the silt, sand and debris. The material remaining after seiving was fixed in 70% ethyl alcohol until the organisms could be identified and counted back in the laboratory.

The second phase of the biological study was an assessment of the magnitude of the Sphaerotilus (slime) growths which were stimulated by waste discharges. The active growth zone of the slime was determined by visual inspection of submerged limbs, rocks, and other objects in the water. The area of the river influenced by drifting slime tufts which had sloughed off from their original point of attachment was determined by slime traps. These traps consisted of cylinders of one-half inch wire mesh which were 9 inches long and 3 inches in diameter. The cylinders were located about 1 foot above the river bed by a line which was anchored with a piece of concrete block and suspended by a one gallon plastic jug float. These samplers were left in position for approximately 24 hours and after that period were picked up and photographed for the record, if they had accumulated slime.

## DISCUSSION OF RESULTS (BIOLOGICAL)

The biological data is presented below in sequential order from upstream to downstream locations. The location of each waste discharge in relation to the sampling station is given. Organisms are identified to family or genus depending on their significance as indicators. Due to time requirements and the fact that they are predominately facultative organisms, the midges (Tendipedidae) were not identified to genus with the exception of the bloodworm (Chironomus sp.) which is an indicator of pollution. Where organisms were collected by dredging a sample of known area (9 inches square) numerical densities are given in numbers of organisms per square foot. Beside each family or genus is the designation C, F, or P. These are symbols designating the condition of water quality in which this type of organism is most commonly found.

C stands for clean-water and indicates that the particular kind or group of organisms requires a continuous good water-quality condition. F stands for facultative, meaning that the organism may adapt to either a high or low water-quality situation but cannot withstand severe pollution. P stands for the pollution tolerant group representing those organisms likely to be present in polluted conditions.

The following biological samples were collected at Keokuk on September 9 and 10, 1969.

Mile 363.2: A qualitative collection from shoreline rocks just downstream from the Corps of Engineers dock, relatively quiet water area. There was an abundant population of mayflies in this area along with associated forms of aquatic life. Normal biological condition.

| | | |
|---|---|---|
| Stenonema sp. | C ) | |
| Amphiagrion sp. | F ) | |
| Pleurocera sp. | F ) | All abundant |
| Asellus sp. | F ) | |
| Turbellaria | F ) | |

Mile 362.4: 10 yards from shore about 0.4 mile below the Keokuk Waste Treatment Plant and Hubbinger Company discharges. The bottom substrate was in very poor condition with a strong odor and blackened appearance. The condition was polluted.

| | | |
|---|---|---|
| Hexagenia sp. | F | 4 per sq.ft. |
| Chironomus sp. | P | 4 " |
| Oligochaetes | P | 10-20 " |

Mile 362.4: 60 yards from Iowa shore, gravel and sand bottom, physical appearance good, normal biological condition.

| | | |
|---|---|---|
| Potamenthus sp. | C | 55 per sq.ft. |
| Hexagenia sp. | F | 2 " |
| Stenelmis sp. | F | 2 " |
| Unidentified Tendipedidae | F | 4 " |
| Unidentified Unionidae | F | 2 " |

Mile 362.2: 20 yards from the Iowa shore, sand, gravel

and detritus substrate, poor physical condition; polluted.

| | | |
|---|---|---|
| *Hexagenia sp.* | F | 2 per sq.ft. |
| *Chironomus sp.* | P | 5 " |
| *Oligochaetes* | P | < 50 " |

Mile 361.6: 30 yards from the Iowa shore, about 200 yards upstream from the mouth of the Des Moines River, muck and gravel substrate, poor physical appearance, polluted condition.

| | | |
|---|---|---|
| *Hexagenia sp.* | F | 2 per sq.ft. |
| *Hydropsyche sp.* | C | 1 " |
| Unidentified Unionidae | F | 2 " |
| *Propterus sp.* | P | 2 " |
| *Oligochaetes* | P | 50-100 " |

Mile 361.6: 100 yards from Iowa shore, sand and good substrate, physical condition indicative of waste but not severe, transition area but still polluted.

| | | |
|---|---|---|
| *Hexagenia sp.* | F | 4 per sq. ft. |
| Unidentified Tendipedidae | F | 7 " |
| *Chironomus sp.* | P | 12 " |
| *Pleurocera sp.* | F | 4 " |
| *Campeloma sp.* | F | 2 " |
| Unidentified Unionidae (2 genera) | F | 4 " |
| *Quadrula sp.* | F | 2 " |

Mile 361.5: 20 yards from the Iowa bank, 50 yards upstream from the Des Moines River confluence. The physical condition at this station was poor, however, there were some organisms present. Many silvery particles similar in appearance to mica were present, however, these were not observed at other stations and are presumed to be related to waste discharges in the area.

| | | |
|---|---|---|
| *Hexagenia sp.* | F | 20 per sq.ft. |
| Unidentified Tendipedidae (3 genera) | F | 7 " |
| Oligochaetes | P | 50-100 " |

Mile 361.4 - 0.1: In the Des Moines River along the Iowa bank, muck bottom.

| | | |
|---|---|---|
| Caenis sp. | C | 2 per sq.ft. |
| Hydropsyche sp. | C | 4 " |
| Hexagenia sp. | F | 14 " |
| Oligochaetes | P | 50-100 " |

Mile 361.4 - 0.05: In the Des Moines River along the Iowa bank, muck bottom.

| | | |
|---|---|---|
| Hexagenia sp. | F | 14 per sq.ft. |
| Potamenthus sp. | C | 2 " |
| Hydropsyche sp. | C | 16 " |
| Unidentified Tendipedidae | F | 2 " |
| Oligochaetes | P | 40-60 " |

The above two stations, located in the Des Moines River near its mouth were not in the best physical of biological condition as indicated by the appearance of the bottom substrates and the numbers of Oligochaete worms which were present. However, there was a fair diversity of aquatic life including some clean water forms and this is believed to be a normal condition for the Des Moines at this location.

Mile 360.8: 10 yards from the Iowa shore, 0.9 mile below the confluence of the Des Moines River, muck, fine sand and detritus substrate. Had other stations not been sampled in this area, one would assume on the basis of this sample that pollution existed. This particular sample was unexplainably poor in biological life, even though the physical condition of the bottom was good; however, the poor biological condition was not typical for this area as proven in the following results.

| | | |
|---|---|---|
| Hexagenia sp. | F | 2 per sq.ft. |
| Unidentified Tendipedidae | F | 2 " |
| Oligochaetes | P | 100-200 " |

Mile 360.8: Illinois side about 15 yards from lower tip of unnamed island; mixed gravel, sand and detritus substrate, normal condition.

| | | |
|---|---|---|
| Hexagenia sp. | F | 82 per sq.ft. |
| Unidentified Tendipedidae (4 genera) | F | 32 " |
| Hirudinea | F | 4 " |
| Chaoburus sp. | P | 2 " |
| Oligochaetes | P | < 20 " |

Mile 360.8: Illinois side between island and Illinois shore, muck and sand bottom, normal condition.

| | | | |
|---|---|---|---|
| *Hexagenia sp.* | F | 39 | per sq.ft. |
| *Unidentified* Tendipedidae | F | 7 | " |
| Sphaeriidae | F | 2 | " |
| Unidentified Unionidae | F | 2 | " |
| Olligochaetes | P | < 50 | |

Mile 360.5: 10 yards from the Iowa shore, muck, sand and detritus substrate, good physical condition. This sample was one of the most productive, biologically, of all locations sampled. Many species were present in abundance and the biological condition was excellent.

| | | | |
|---|---|---|---|
| *Caenis sp.* | C | 148 | per sq.ft. |
| *Stenonema sp.* | C | 14 | " |
| *Isonychia sp.* | C | 12 | " |
| *Leptocera sp.* | C | 7 | " |
| *Hydropsyche sp.* | C | 12 | " |
| *Neureclipsis sp.* | C | 4 | " |
| *Amphiagrion sp.* | F | 7 | " |
| *Gomphus sp.* | F | 29 | " |
| *Stenelmis sp.* | F | 4 | " |
| *Unidentified* Tendipedidae (4 genera) | F | 27 | " |
| Turbellaria | F | 7 | " |
| *Chironomus sp.* | P | 2 | " |
| *Oligochaetes* | P | < 20 | " |

Mile 359.3: 35 yards from the Iowa shore; sand and muck substrate, physical appearance good, condition normal.

| | | | |
|---|---|---|---|
| *Caenis sp.* | C | 2 | per sq.ft. |
| *Hexagenia sp.* | F | 57 | " |
| *Gomphus sp.* | F | 4 | " |
| *Unidentified* Tendipedidae (2 genera) | F | 5 | " |
| Sphaeriidae | F | 2 | " |
| Oligochaetes | P | 200-250 | " |

Mile 359.3: 75 yards from the Iowa shore; muck, sand and detritus substrate, good physical appearance.

| | | | |
|---|---|---|---|
| *Hexagenia sp.* | F | 21 | per sq.ft. |
| *Gomphus sp.* | F | 2 | " |

| | | |
|---|---|---|
| Unidentified Tendipedidae (2 genera) | F | 4 per sq.ft. |
| *Chaoborus sp.* | P | 2 " |
| *Oligochaetes* | P | < 20 " |

Mile 359.3: mid-river, 250 yards from the Iowa shore, clean sand bottom with no significant numbers of organisms which is normal.

Mile 359.3: 100 yards from the Illinois bank, clean sand and gravel substrate, normal biological condition.

| | | |
|---|---|---|
| *Potamanthus sp.* | C | 5 per sq.ft. |
| *Hydropsyche sp.* | C | 5 " |
| *Hexagenis sp.* | F | 2 " |
| Unidentified Tendipedidae (2 genera) | F | 4 " |
| *Chironomus sp.* | P | 2 " |
| *Oligochaetes* | P | < 10 " |

Mile 358.5: 30 yards from the Iowa bank; muck, sand and detritus substrate, excellent biological condition.

| | | |
|---|---|---|
| *Caenis sp.* | C | 4 per sq.ft. |
| *Hydropsyche sp.* | C | 2 " |
| *Hexagenia sp.* | F | 68 " |
| *Gomphus sp.* | F | 2 " |
| Unidentified Tendipedidae (2 genera) | F | 4 " |
| Hirudinea | F | 2 " |
| Oligochaetes | P | < 20 " |

Mile 358.5: Qualitative collection from rocks along shoreline, excellent biological condition. Stoneflies have rarely been collected during the laboratory's Mississippi studies this summer, however, 3 large nymphs (*Acroneuria sp.*) were collected at this spot. All organisms were relatively abundant.

| | |
|---|---|
| *Acroneuria sp.* | C |
| *Stenonema sp.* | C |
| *Hydropsyche sp.* | C |
| *Stenelmis sp.* | F |
| *Tendipedidae* | F |
| *Pleurocera sp.* | F |
| *Physa sp.* | F |
| *Amphiagrion sp.* | F |

Mile 359.1: rocks along the Illinois shore were inspected and the condition was found to be good. Biota was similar to that observed near the Iowa shore.

The biological condition of the Mississippi River above Keokuk waste discharges and on the Illinois side of the river is excellent, however, from the mouth of Soap Creek (mile 362.9) to the mouth of the Des Moines River (mile 361.4) the biological condition indicates severe pollution. The worst of this condition seems to be limited to a strip of the river along the Iowa shore which varies from 60 - 100 yards wide.

When this section of polluted water meets the Des Moines River, rather than mixing with the Des Moines flow, the majority of the waste is pushed out toward the main channel where it continues on downstream. From that point on the Keokuk waste is gradually mixed with the total river flow.

Due to this rather unique situation there is practically no effect on the Missouri side of the river for at least the first three miles downstream from the Des Moines River. At mile 359.3 (about 2 miles downstream from the Des Moines) four dredge samples were taken at intervals across the river. None of these samples indicated a polluted condition, however, if the majority of the waste were still in a relatively small cross-section of the river, this would have easily been missed for the total river width is about 800 yards at this point. The above discussion is not meant to leave the impression that a deteriorated biological condition could not result at some point further downstream as a result of wastes discharged in the Keokuk area. This may well occur as a result of the abundant quantities of slime (<u>Sphaerotilus natans</u>) growths which were stimulated by the Hubbinger Company and Keokuk Sewage Treatment Plant discharges. Slime samplers were placed along the shore in the area between the Des Moines River mouth (mile 361.4) and the first waste discharge (mile 362.9). Two samplers were also placed downstream from the Des Moines River mouth at mile 361. One of these samplers was located 10 yards from the bank and the other at the edge of the navigational channel, about 75 yards from the Missouri shore. Samplers above the Des Moines trapped large quantities of the drifting Sphaerotilus, however, both samplers below the Des Moines River mouth were free of slime indicating that this material had also been puched out toward the main channel of the river. As this large quantity of slime is carried downstream, it eventually will settle to the bottom in quiet water areas and decompose, in this way posing a threat to the bottom dwelling organisms. The slime growths are known to cause a problem in Missouri wastes because official complaints have been received from Missouri regarding this matter.

DISCUSSION OF RESULTS (CHEMISTRY AND BACTERIOLOGY)

The complete chemical and bacteriological data are in Tables 1 - 7 of this report.

Water quality at mile 363.9, above all Keokuk waste sources and below lock and dam 19, was different from that generally observed in control areas upstream from the larger cities. The difference was primarily higher ammonia-nitrogen concentrations (0.3 mg/l versus < 0.1 mg/l) and slightly lower dissolved oxygen concentrations (5.5 - 5.9 mg/l versus 6 - 7 mg/l). This change in water quality is not believed to be due to upstream waste discharges but rather to the unique situation which exists at Keokuk. Pool 19, above the lock and dam, resembles a lake rather than a river, and is 47 miles long with a width up to 2 miles. At the lock and dam, this pool is approximately 40 feet deep. With this situation it is very likely that there is some difference in water quality between the surface layers and the deeper layers of the pool because of limited mixing. One would expect that dissolved oxygen concentrations in the deeper water of the pool would be lower because of reduced photosynthetic activity and that ammonia concentrations would tend to rise. This has not been verified by sampling but it is a reasonable assumption.

Having theorized that the deeper waters of pool 19 have higher ammonia and lower dissolved oxygen concentrations, the question remaining is why should only the deep water be discharged through the dam structure? The answer to this is the Union Electric Company, a hydroelectric facility which uses the majority of the river flow at lock and dam 19 to generate power. There are 17 large openings (each 22 feet high by 8 feet wide) at the bottom of the pool through which the water

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TABLE 1

| | | | | |
|---|---|---|---|---|
| Town or Station | Keokuk | | | |
| Source | Mississippi River | | | |
| Specific Location | Mile 363.9 - Under RR & Hwy bridge, 15 yds from lock wall on Iowa side | | Mile 363.9 Mid-river, 250 yds from lock wall | Mile 363.9 75 yds from Illinois shore |
| Date Collected | 8 Sep 69 | | | |
| Date Received | 10 Sep 69 | | | |
| Bottle Number | | | | |
| Bottle Number | | | | |
| Laboratory Number | 1231 | | 1232 | 1233 |
| Bacterial: Exam. By | | | | |
| XXXXX Coliform/100 ml. | 400 | | 200 | 500 |
| Chemical: (MG/L) Exam. By | | | | |
| Fluoride DMB | | | | |
| Local | | | | |
| Detergents (ABS) | | | | |
| CSCFE | | | | |
| pH Value | 7.7 | | 7.7 | 7.7 |
| Alkalinity P | None | | None | None |
| T | 174 | | 176 | 176 |
| Turbidity (Est) | 77 | | 100 | 110 |
| Organic Nitrogen As N | 0.80 | | 0.75 | 0.69 |
| Ammonia Nitrogen As N | 0.24 | | 0.25 | 0.35 |
| Nitrite Nitrogen As N | 0.030 | | 0.028 | 0.031 |
| Nitrate Nitrogen As N | 0.7 | | 0.7 | 0.7 |
| Total Nitrogen As N | | | | |
| Total Solids | 300 | | 308 | 322 |
| Fixed Solids | 194 | | 196 | 202 |
| Volatile Solids | 106 | | 112 | 120 |
| Total Suspended Solids | 42 | | 46 | 72 |
| Fixed Suspended Solids | 38 | | 46 | 62 |
| Volatile Suspended Solids | 4 | | 0 | 10 |
| Total Dissolved Solids | 258 | | 262 | 250 |
| Fixed Dissolved Solids | 156 | | 150 | 140 |
| Volatile Dissolved Solids | 102 | | 112 | 110 |
| Soluble Phosphate ($PO_4$) | 0.5 | | 0.4 | 0.4 |
| Total Phosphate ($PO_4$) | 0.5 | | 0.4 | 0.5 |
| Dissolved Oxygen | 5.9 | | 5.5 | 5.6 |
| B. O. D. 5-day 20° C. | 3 | | 2 | 2 |
| COD | 16.7 | | 14.6 | 18.7 |
| Total Hardness mg/l | 212 | | 216 | 216 |
| " " gpg | 12.4 | | 12.6 | 12.6 |
| Field Data: | | | | |
| Time | 3:20 pm | | 3:30 pm | 3:35 pm |
| Remarks: Water Temp °C | 24.8 | | 24.8 | 25 |
| pH | 8.0 | | 8.0 | 8.0 |

Collector Gakstatter, Pierson, Briedis

Report To WPCC

R. L. Morris, Ph.D.
JHG Assistant Director & Principal Chemist

16 Sep 69 bj

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TABLE 2

| | | | | |
|---|---|---|---|---|
| Town or Station | Keokuk | | | |
| Source | Mississippi River | | | |
| Specific Location | Mile 362.9 - 50 yds upstream from Soap Creek, 25 yds from shore | | Mile 362.85 40 yds below Soap Creek, 15 yds from shore, 3 ft deep | Mile 362.6 About 250 yds below STP, 20 yds from Iowa shore |
| Date Collected | 8 Sep 69 | | | |
| Date Received | 10 Sep 69 | | | |
| Bottle Number | | | | |
| Bottle Number | | | | |
| Laboratory Number | 1234 | | 1235 | 1236 |
| Bacterial: Exam. By | | | | |
| ~~M.P.N.~~ Coliform/100 ml. | 200 | | 460,000 | 480,000 |
| | | | | |
| Chemical: (MG/L) Exam. By | | | | |
| Fluoride DMB | | | | |
| Local | | | | |
| Detergents (ABS) | | | | |
| CSCFE | | | | |
| pH Value | | | | |
| Alkalinity P | | | | |
| T | | | | |
| | | | | |
| Turbidity (Est) | 100 | | 120 | 85 |
| Organic Nitrogen As N | 0.69 | | 3.3 | 1.4 |
| Ammonia Nitrogen As N | 0.21 | | 0.08 | 0.05 |
| Nitrite Nitrogen As N | 0.029 | | 0.004 | 0.023 |
| Nitrate Nitrogen As N | 0.7 | | 0.3 | 0.8 |
| Total Nitrogen As N | | | | |
| Total Solids | 312 | | 382 | 336 |
| Fixed Solids | 198 | | 202 | 198 |
| Volatile Solids | 114 | | 180 | 138 |
| Total Suspended Solids | 40 | | 80 | 60 |
| Fixed Suspended Solids | 38 | | 50 | 52 |
| Volatile Suspended Solids | 2 | | 30 | 8 |
| Total Dissolved Solids | 272 | | 302 | 276 |
| Fixed Dissolved Solids | 160 | | 152 | 146 |
| Volatile Dissolved Solids | 112 | | 150 | 130 |
| Soluble Phosphate ($PO_4$) | 0.3 | | 0.2 | 0.3 |
| Total Phosphate ($PO_4$) | 0.4 | | 0.6 | 0.5 |
| Dissolved Oxygen | 5.9 | | 2.9 | 5.3 |
| B. O. D. 5-day 20° C. | 2 | | 20 | 7 |
| | | | | |
| COD | 14.6 | | 91.7 | 29.2 |
| Field Data: | | | | |
| Time | 3:50 pm | | 3:45 pm | 4:00 pm |
| Water Temp °C | 24.8 | | 25.2 | 25 |
| pH | 8.0 | | 7.75 | 7.8 |

Remarks:

Collector Gakstatter, Pierson, Briedis

Report To WPCC

R. L. Morris, Ph.D.
JHG Assistant Director & Principal Chemist

16 Sep 69 bj

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Des Moines 9, Iowa

TABLE 3

| | | | | |
|---|---|---|---|---|
| Town or Station | Keokuk | | | |
| Source | Mississippi River | | | |
| Specific Location | Mile 362.6 -100 yds from shore | Mile 362.2 - Just above Kemco discharges, 30 yds from shore | Mile 361.6 - Above mouth of Des Moines River, 30 yds from Iowa shore | Mile 361.6 - Iowa side of main channel, 300 yds from Iowa shore |
| Date Collected | 8 Sep 69 | | | |
| Date Received | 10 Sep 69 | | | |
| Bottle Number | | | | |
| Bottle Number | | | | |
| Laboratory Number | 1237 | 1238 | 1239 | 1240 |
| Bacterial: Exam. By | | | | |
| XXXX Coliform/100 ml. | 100 | 220,000 | 660,000 | < 100 |
| Chemical: (MG/L) Exam. By | | | | |
| Fluoride DMB | | | | |
| Local | | | | |
| Detergents (ABS) | | | | |
| CSCFE | | | | |
| pH Value | | | 7.5 | 7.8 |
| Alkalinity P | | | None | None |
| T | | | 178 | 176 |
| | | | | |
| Turbidity (Est) | 85 | 71 | 110 | 77 |
| Organic Nitrogen As N | 0.68 | 0.81 | 1.2 | 0.68 |
| Ammonia Nitrogen As N | 0.23 | 0.13 | 0.01 | 0.19 |
| Nitrite Nitrogen As N | 0.028 | 0.028 | 0.024 | 0.029 |
| Nitrate Nitrogen As N | 0.8 | 0.8 | 0.7 | 0.7 |
| Total Nitrogen As N | | | | |
| Total Solids | 304 | 314 | 350 | 302 |
| Fixed Solids | 180 | 186 | 206 | 184 |
| Volatile Solids | 124 | 128 | 144 | 118 |
| Total Suspended Solids | 34 | 42 | 76 | 20 |
| Fixed Suspended Solids | 32 | 36 | 46 | 20 |
| Volatile Suspended Solids | 2 | 6 | 30 | 0 |
| Total Dissolved Solids | 304 | 272 | 274 | 282 |
| Fixed Dissolved Solids | 180 | 150 | 160 | 164 |
| Volatile Dissolved Solids | 124 | 122 | 114 | 118 |
| Soluble Phosphate ($PO_4$) | 0.3 | 0.4 | 0.2 | 0.4 |
| Total Phosphate ($PO_4$) | 0.4 | 0.5 | 0.6 | 0.5 |
| Dissolved Oxygen | 6.1 | 5.9 | 4.2 | 5.9 |
| B.O.D. 5-day 20° C. | < 1 | 1 | 2 | 2 |
| COD | 14.6 | 20.8 | 31.2 | 14.6 |
| Total Hardness mg/l | | | 220 | 216 |
| " " gpg | | | 12.8 | 12.6 |
| Field Data: | | | | |
| Time | 4:10 pm | 4:20 pm | 5:05 pm | 5:15 pm |
| Remarks: Water Temp °C | 24.8 | 24.8 | 24.9 | 24.9 |
| pH | 7.95 | 8.0 | 7.8 | 7.95 |

Collector Gakstatter, Pierson, Briedis

Report To WPCC

R. L. Morris, Ph.D.
JHG Assistant Director & Principal Chemist
16 Sep 69 bj

1341

STATE HYGIENIC LABORATORY

Des Moines Branch
405 State Office & Lab Bldg.
East 7th & Court
Des Moines 9, Iowa

TABLE 4

| | | | | |
|---|---|---|---|---|
| Town or Station | Keokuk | | | |
| Source | Mississippi River | | | |
| Specific Location | Mile 361.6-Ill | Mile 363.1 - | Mile 361.6 - | Mile 361.6 - |
| side, 35 yds from | bank of island | 25 yds from | 40 yds from | 120 yds from |
| Date Collected | 8 Sep 69 | shore | Iowa bank | Iowa bank |
| Date Received | 10 Sep 69 | Coll: 9 Sep 69 | | |
| Bottle Number | | Rcd: 10 Sep 69 | | |
| Bottle Number | | | | |
| Laboratory Number | 1241 | 1242 | 1243 | 1244 |
| Bacterial: Exam. By | | | | |
| MF XXXX Coliform/100 ml. | < 1000 | < 100 | 250,000 | 300 |
| Chemical: (MG/L) Exam. By | | | | |
| Fluoride DMB | | | | |
| Local | | | | |
| Detergents (ABS) | | | | |
| CSCFE | | | | |
| pH Value | 7.8 | 7.8 | | |
| Alkalinity P | None | None | | |
| T | 176 | 176 | | |
| Turbidity (Est) | 110 | 71 | 77 | 68 |
| Organic Nitrogen As N | 0.87 | 0.76 | 1.1 | 0.76 |
| Ammonia Nitrogen As N | 0.31 | 0.20 | 0.01 | 0.19 |
| Nitrite Nitrogen As N | 0.030 | 0.035 | 0.024 | 0.036 |
| Nitrate Nitrogen As N | 0.6 | 0.6 | 0.6 | 0.7 |
| Total Nitrogen As N | | | | |
| Total Solids | 318 | 304 | 312 | 308 |
| Fixed Solids | 192 | 180 | 172 | 178 |
| Volatile Solids | 126 | 124 | 140 | 130 |
| Total Suspended Solids | 44 | 24 | 28 | 48 |
| Fixed Suspended Solids | 40 | 20 | 20 | 46 |
| Volatile Suspended Solids | 4 | 4 | 8 | 2 |
| Total Dissolved Solids | 274 | 280 | 284 | 260 |
| Fixed Dissolved Solids | 152 | 160 | 152 | 132 |
| Volatile Dissolved Solids | 122 | 120 | 132 | 128 |
| Soluble Phosphate ($PO_4$) | 0.4 | 0.3 | 0.3 | 0.5 |
| Total Phosphate ($PO_4$) | 0.5 | 0.4 | 0.5 | 0.5 |
| Dissolved Oxygen | 5.4 | 5.8 | 4.4 | 5.8 |
| B. O. D. 5-day 20° C. | 1 | 2 | 2 | < 1 |
| COD | 18.7 | 16.7 | 27.1 | 16.7 |
| Total Hardness mg/l | 216 | 216 | | |
| " " gpg | 12.6 | 12.6 | | |
| Field Data: | | | | |
| Time | 5:20 pm | 11:20 am | 10:45 am | 10:50 am |
| Remarks: Temp °C | 24.9 | 24.5 | 24.5 | |
| pH | 7.9 | 8.0 | 7.75 | 8.0 |

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Des Moines 9, Iowa

TABLE 5

| | | | | |
|---|---|---|---|---|
| Town or Station | Keokuk | | | |
| Source | Mississippi River | | | |
| Specific Location from Iowa shore, | Mile 361.6 - About 250-300 yds on Illinois edge of channel, | (75 yds below lighted buoy) | Mile 361.3 - In Des Moines River, 100 yds from Mississippi | Mile 361 - 20 yds from Missouri shore |
| Date Collected | 9 Sep 69 | | | |
| Date Received | 10 Sep 69 | | | |
| Bottle Number | | | | |
| Bottle Number | | | | |
| Laboratory Number | 1245 | | 1246 | 1247 |
| Bacterial: Exam. By | | | | |
| XXXX. Coliform/100 ml. | < 100 | | 2500 | 2000 |
| Chemical: (MG/L) Exam. By | | | | |
| Fluoride DMB | | | | |
| Local | | | | |
| Detergents (ABS) | | | | |
| CSCFE | | | | |
| pH Value | | | 8.0 | |
| Alkalinity P | | | None | |
| T | | | 198 | |
| Turbidity (Est) | 82 | | 210 | 180 |
| Organic Nitrogen As N | 0.79 | | 0.92 | 0.84 |
| Ammonia Nitrogen As N | 0.19 | | 0.03 | 0.01 |
| Nitrite Nitrogen As N | 0.033 | | 0.033 | 0.034 |
| Nitrate Nitrogen As N | 0.7 | | 2.0 | 2.0 |
| Total Nitrogen As N | | | | |
| Total Solids | 294 | | 554 | 526 |
| Fixed Solids | 168 | | 394 | 378 |
| Volatile Solids | 126 | | 160 | 148 |
| Total Suspended Solids | 64 | | 188 | 126 |
| Fixed Suspended Solids | 60 | | 178 | 108 |
| Volatile Suspended Solids | 4 | | 10 | 18 |
| Total Dissolved Solids | 230 | | 366 | 400 |
| Fixed Dissolved Solids | 108 | | 216 | 270 |
| Volatile Dissolved Solids | 122 | | 150 | 130 |
| Soluble Phosphate ($PO_4$) | 0.3 | | 0.2 | 0.2 |
| Total Phosphate ($PO_4$) | 0.5 | | 0.5 | 0.4 |
| Dissolved Oxygen | 5.9 | | 7.0 | 7.0 |
| B. O. D. 5-day 20° C. | < 1 | | < 1 | 1 |
| COD | 18.7 | | 20.8 | 16.7 |
| Total Hardness mg/l | | | 276 | |
| " " gpg | | | 16.1 | |
| Field Data: | | | | |
| Time | 11:00 am | | 8:40 am | 8:55 am |
| Remarks: Water Temp °C | 24.4 | | 23.5 | 23.5 |
| pH | 8.0 | | 7.9 | 7.9 |

Collector Gakstatter, Pierson, Briedis

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# STATE HYGIENIC LABORATORY

Des Moines Branch
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## TABLE 6

| | | | | |
|---|---|---|---|---|
| Town or Station | Keokuk | | | |
| Source | Mississippi River | | | |
| Specific Location | Mile 361-mid-river, 270 yds from Mo. shore | Mile 361-25 yds from west side of Island on Illinois side | Mile 359 - 50 yds from Mo. shore | Mile 359 - 225 yds from Mo. shore |
| Date Collected | 9 Sep 69 | | | |
| Date Received | 10 Sep 69 | | | |
| Bottle Number | | | | |
| Bottle Number | | | | |
| Laboratory Number | 1248 | 1249 | 1250 | 1251 |
| Bacterial: Exam. By | | | | |
| MF Coliform/100 ml. | 500 | < 100 | 46,000 | 5600 |
| Chemical: (MG/L) Exam. By | | | | |
| Fluoride DMB | | | | |
| Local | | | | |
| Detergents (ABS) | | | | |
| CSCFE | | | | |
| pH Value | | | | |
| Alkalinity P | | | | |
| T | | | | |
| Turbidity (Est) | 71 | 82 | 120 | 110 |
| Organic Nitrogen As N | 0.77 | 0.73 | 0.77 | 0.79 |
| Ammonia Nitrogen As N | 0.23 | 0.21 | 0.08 | 0.17 |
| Nitrite Nitrogen As N | 0.034 | 0.036 | 0.039 | 0.037 |
| Nitrate Nitrogen As N | 0.7 | 0.7 | 1.3 | 0.9 |
| Total Nitrogen As N | | | | |
| Total Solids | 440 | 336 | 366 | 354 |
| Fixed Solids | 332 | 232 | 238 | 274 |
| Volatile Solids | 108 | 104 | 128 | 80 |
| Total Suspended Solids | 134 | 42 | 16 | 66 |
| Fixed Suspended Solids | 134 | 40 | 0 | 64 |
| Volatile Suspended Solids | 0 | 2 | 16 | 2 |
| Total Dissolved Solids | 306 | 249 | 350 | 288 |
| Fixed Dissolved Solids | 198 | 192 | 238 | 210 |
| Volatile Dissolved Solids | 108 | 102 | 112 | 78 |
| Soluble Phosphate ($PO_4$) | 0.3 | 0.3 | 0.2 | 0.3 |
| Total Phosphate ($PO_4$) | 0.5 | 0.4 | 0.4 | 0.5 |
| Dissolved Oxygen | 5.8 | 5.8 | 6.2 | 5.9 |
| B. O. D. 5-day 20° C. | < 1 | < 1 | 1 | < 1 |
| COD | 22.9 | 20.8 | 16.7 | 18.7 |
| Field Data: | | | | |
| Time | 9:05 am | 9:10 am | 9:20 am | 9:25 am |
| Water Temp °C | 24.2 | 24.0 | 23.8 | 24.5 |
| pH | 7.9 | 7.85 | 7.95 | 7.9 |

Remarks:

Collector Gakstatter, Pierson, Briedis

Report To WPCC

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STATE HYGIENIC LABORATORY
Des Moines Branch
405 State Office & Lab Bldg.
East 7th & Court
Des Moines 9, Iowa

TABLE 7

| | | | | |
|---|---|---|---|---|
| Town or Station | Keokuk | | | |
| Source | Mississippi River | | | |
| Specific Location | Mile 359 - 30 yds from Illinois shore | Mile 354.3 - 40 yds from Missouri shore | Mile 354.3- Mid-river | Mile 354.3 - 50 yds from Island on Illinois side |
| Date Collected | 9 Sep 69 | | | |
| Date Received | 10 Sep 69 | | | |
| Bottle Number | | | | |
| Bottle Number | | | | |
| Laboratory Number | 1252 | 1253 | 1254 | 1255 |
| Bacterial: Exam. By | | | | |
| FXXXX. Coliform/100 ml. | 300 | 22,000 | 6500 | 300 |
| Chemical: (MG/L) Exam. By | | | | |
| Fluoride DMB | | | | |
| Local | | | | |
| Detergents (ABS) | | | | |
| CSCFE | | | | |
| pH Value | | 7.9 | 7.9 | 7.9 |
| Alkalinity P | | None | None | None |
| T | | 190 | 180 | 178 |
| Turbidity (Est) | 85 | 120 | 94 | 79 |
| Organic Nitrogen As N | 0.79 | 0.76 | 0.87 | 0.77 |
| Ammonia Nitrogen As N | 0.31 | 0.05 | 0.13 | 0.17 |
| Nitrite Nitrogen As N | 0.036 | 0.050 | 0.042 | 0.039 |
| Nitrate Nitrogen As N | 0.7 | 1.4 | 0.9 | 0.7 |
| Total Nitrogen As N | | | | |
| Total Solids | 312 | 380 | 340 | 324 |
| Fixed Solids | 216 | 266 | 230 | 216 |
| Volatile Solids | 96 | 114 | 110 | 108 |
| Total Suspended Solids | 36 | 60 | 54 | 36 |
| Fixed Suspended Solids | 36 | 60 | 46 | 28 |
| Volatile Suspended Solids | 0 | 0 | 8 | 8 |
| Total Dissolved Solids | 276 | 320 | 286 | 288 |
| Fixed Dissolved Solids | 180 | 206 | 184 | 188 |
| Volatile Dissolved Solids | 96 | 114 | 102 | 100 |
| Soluble Phosphate ($PO_4$) | 0.3 | 0.2 | 0.4 | 0.3 |
| Total Phosphate ($PO_4$) | 0.5 | 0.3 | 0.5 | 0.5 |
| Dissolved Oxygen | 5.8 | 6.3 | 6.0 | 6.2 |
| B. O. D. 5-day 20° C. | 2 | 8 | 2 | 2 |
| COD | 22.9 | 16.7 | 20.8 | 22.9 |
| Total Hardness mg/l | | 248 | 224 | 220 |
| " " gpg | | 14.5 | 13.1 | 12.8 |
| Field Data: Time | 9:35 am | 9:50 am | 10:00 am | 10:05 am |
| Remarks: Water Temp °C | 23.8 | 24 | 24.7 | 24.2 |
| pH | 7.8 | 7.75 | 7.8 | 7.9 |

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flows to turn the turbines. At river flows up to 60,000 cfs the total discharge is used for power generation which means that essentially all of the water downstream from the power plant originated from the lower depths of pool 19. This accounts for the elevated ammonia concentration and slightly lower dissolved oxygens which were observed at mile 363.9, above Keokuk waste sources.

Fecal coliform bacteria were present in relatively low numbers at all stations at mile 363.9 (above Keokuk waste sourves). From the Iowa to the Illinois side of the river, numbers of fecal coliforms per 100 milliliters of water were 400, 200 and 500 respectively.

Between Soap Creek (mile 362.9) and the Hubbinger-Keokuk STP outfall (mile 362.8) the water was seriously degraded with a dissolved oxygen concentration of 2.9 mg/l, high organic nitrogen, high BOD and high solids content. At the time, this was primarily due to raw sewage discharged by the municipal plant into Soap Creek because of a defective lift station pump, however, during the February survey the same condition existed because of the Hubbinger discharge into Soap Creek.

From a point below the Hubbinger-city outfall (mile 362.8) to the Des Moines River mouth (361.4) water quality was very poor along the Iowa bank. This area was characterized by heavy bacterial contamination (220,000-660,000 fecal coliforms per 100 milliliters water), high organic nitrogen concentrations and low dissolved oxygens. At mile 361.6, just upstream from the Des Moines River mouth, dissolved oxygen concentrations were 4.2 and 4.4 mg/l on two different days indicating that Iowa Water Quality Standard for dissolved oxygen was not being met in this area.

The chemistry and bacteriology of the water showed a very close relationship with the biological findings. This was that the area affected by the wastes discharged at Keokuk was restricted to a strip of water in the order of 100 yards wide between the first waste discharge (mile 362.9) and the mouth of the Des Moines (mile 361.4)

The quality of the Des Moines River water was quite different from that in the Mississippi. Bacterial (fecal coliform) numbers in the Des Moines were 2500 organisms per 100 milliliters as compared to 100 - 500 in the

Mississippi. Total solids were nearly twice as much in the Des Moines River as in the Mississippi. Turbidity, organic nitrogen, nitrate-nitrogen and hardness were all higher in the Des Moines River, however the BOD was about the same or perhaps slightly less in the Des Moines (< 1 mg/l) than in the Mississippi (1-3 mg/l). Because of these large differences in water quality, it was relatively easy downstream to determine how rapidly Des Moines River flow blended with the Mississippi water.

The chemistry and bacteriology of the Mississippi downstream from the Des Moines also indicated that Keokuk wastes were pushed toward mid-river by the Des Moines River flow. At mile 361 (0.4 mile below the Des Moines mouth) 20 yards from the Missouri shore, water quality was almost identical with that in the Des Moines River proper. 270 yards from the Missouri shore and on the Illinois side, water quality was similar to that above Keokuk. This indicated that the Keokuk waste was restricted to a point between 20 and 270 yards from the Missouri side. At mile 359 (2.4 miles downstream from the Des Moines), samples 50 and 225 yards from the Missouri shore indicated a mixture of Des Moines River water and Keokuk waste. There was heavy bacterial contamination from Keokuk in the samples taken 50 and 225 yards from the Missouri shore. Across the river from the Missouri to the Illinois side, numbers of fecal coliforms per 100 milliliters were 46,000, 5600 and 300.

At mile 354.3 (7.1 miles below the Des Moines and 8.6 miles below the first Keokuk waste discharge), Keokuk waste was still causing substantial bacterial contamination. Forty yards from the Missouri shore and at mid-river fecal coliform concentrations were 22,000 and 6500 per 100 milliliters of water as compared to 300 on the Illinois side. The influence of Des Moines River quality was also evident in the Missouri side and mid-river sample.

During the October, 1968 survey as well as the present one, some Keokuk residents complained that the municipal water works frequently discharged waste sludge into the Mississippi above the small boat harbor at mile 363.6. This discharge was said to discolor the water and to kill minnows which were being held in live boxes at the boat harbor.

## CONCLUSIONS

Water quality upstream (mile 363.9) from Keokuk waste discharges was good, although ammonia nitrogen concentrations were higher than those normally measured in control areas (0.3 mg/l versus < 0.1 mg/l) and dissolved oxygen concentrations were slightly lower (5.5 - 5.9 mg/l versus 6 - 7 mg/l). This phenomenon is not due to upstream wastes but to the fact that pool 19 above the lock and dam resembles a lake rather than a river and undoubtedly is poorly mixed from surface to bottom. The deeper water would be expected to have higher ammonia and lower dissolved oxygen concentrations and it is primarily the deeper water which is discharged through the hydroelectric turbines by the Union Electric Company at lock and dam 19. Up to a river flow of 60,000 cfs, Union Electric uses the total flow to generate electricity.

Bacterial contamination at mile 363.9 above Keokuk waste discharges was minor with numbers of fecal coliforms per 100 milliliter ranging from 200 - 500 across the river.

Beginning at the mouth of Soap Creek (mile 362.9) and the Hubbinger Company - Keokuk Waste Treatment Plant discharge (mile 362.8) the Mississippi is severely degraded chemically, bacteriologically and biologically down to the mouth of the Des Moines River (mile 361.4). This condition is contributed to by the industrial complex of Keokuk Steel Castings Company and Keokuk Electrometals Company which are located on the Iowa bank between mile 361.7 and mile 363.2. The area of degradation in the area between the first Keokuk discharge (mile 362.9) and the mouth of the Des Moines River (mile 361.4) seems to be limited to a reach of river from 60 - 100 yards wide along the Iowa bank.

Water quality of the Des Moines River as it entered the Mississippi was good, however, it was quite different chemically from Mississippi water. Des Moines River water contained more nitrogenous material, a greater load of suspended and dissolved solids, and about 5 - 6 times the fecal coliform numbers than did Mississippi water upstream from Keokuk wastes.

The flow of the Des Moines tended to push the Mississippi water (and Keokuk waste) toward mid-river at the point where the two rivers met. In the Mississippi, 0.4 miles downstream (mile 361) from the junction of the two rivers, water quality along the Missouri bank was almost identical to that of the Des Moines River water and the Keokuk wastes were flowing somewhere between 20 - 270 yards from the Missouri shore.

At mile 359 (2.3 miles below the Des Moines River and 3.9 miles below the first Keokuk waste discharge) substantial bacterial contamination from Keokuk covered the Missouri half of the river and at mile 354.3 there was still substantial bacterial contamination on the Missouri half of the river. The numbers of fecal coliforms per 100 milliliters from the Missouri to the Illinois side at mile 354.3 (8.6 miles below the first Keokuk waste) were 220,000, 6500, and 300 respectively. On the basis of the observed rate of decrease in bacterial contamination, it could be assumed that substantial numbers of fecal coliform indicators would exist for many more miles downstream in Missouri-Illinois waters.

Abundant Sphaerotilus natans (slime) growths are stimulated by the Hubbinger Company - Keokuk Waste Treatment Plant discharges. Drifting slime was observed along the Iowa shore just above the mouth of the Des Moines River, however, this material was being pushed toward mid-river by the Des Moines water entering the Mississippi. At some point downstream the drifting slime will settle to the bottom and decompose, creating a potential hazard for aquatic life at that point. Official complaints have been received from Missouri regarding slime accumulation on fishermen's nets in Missouri waters below Keokuk.

Although settled slime and other waste associated organic material may be detrimental to aquatic life at some point downstream from the mouth of the Des Moines, studies showed that for a distance of about 3 miles along the Missouri shore (mile 361.4 - 358.5) biological conditions were excellent. This is attributed to the fact that the Des Moines River pushes the Keokuk wastes toward mid-river and they do not have the opportunity to significantly affect the shoreline areas within this 3 mile reach.

Several complaints have been received regarding the alleged practice of the Keokuk Municipal Water Works discharging waste sludge into the Mississippi River. This situation should be further investigated and if the allegations are true, appropriate steps should be taken to remedy this situation.

RECOMMENDATIONS

This report shows that significant chemical and biological degradation exist over a 1.5 mile reach downstream from Keokuk waste sources and that bacteriological contamination exists more than 8.6 miles downstream, involving primarily Missouri-Illinois waters. It is therefore recommended that a condition of pollution be judged.

Jack H. Gakstatter

Jack H. Gakstatter, Ph.D.
Principal Limnologist
State Hygienic Laboratory

R L Morris

Robert L. Morris, Ph.D.
Associate Director and
Principal Chemist
State Hygienic Laboratory

# APPENDIX A

*Chemical and bacteriological Data collected in the Keokuk Area during October, 1968.

*This information was extracted from a Mississippi River report concerning several areas of the river, which was submitted to the Iowa Water Pollution Control Commission in November, 1968.

Table 5. Water quality data for stations at Keokuk

| | Channel Mile 366 | Iowa side Mile 364.2 | Illinois side Mile 364.2 | Soap Creek ~~Bloody Run~~ Mile 363 |
|---|---|---|---|---|
| Fecal coliform | 200 | 200 | 300 | 1,390,000 |
| pH | 7.8 | 7.6 | 7.7 | 6.5 |
| Dissolved Oxygen | 8.3 | 8.2 | 9.7 | 0.0 |
| BOD-5 day | 1 | 1 | $< 1$ | 30 |
| COD | 28.2 | 20.3 | 24.4 | 85.3 |
| Alkalinity | 126 | 124 | 126 | 123 |
| Turbidity | 106 | 84 | 110 | 110 |
| Total Solids: | 258 | 246 | 258 | 336 |
| Suspended | 52 | 26 | 34 | 66 |
| Dissolved | 206 | 220 | 224 | 270 |
| Organic N | .76 | .75 | .75 | 1.80 |
| Ammonia N | .13 | .08 | .11 | .35 |
| Nitrite N | .012 | .007 | .011 | .014 |
| Nitrate N | .60 | .70 | .70 | .60 |
| Soluble $PO_4$ | 0.3 | .4 | .4 | 1.0 |
| Total $PO_4$ | 0.4 | .4 | .4 | 1.5 |
| Hardness | - | 156 | 156 | 172 |
| Collection Date | 10/11/68 | 10/8/68 | 10/8/68 | 10/8/68 |

Table 5. (Continued) Water quality data for stations at Keokuk.

| | Keokuk STP Mile 362.9 | Hubbinger Co. Mile 362.85 | 150 yds. Below STP Mile 362.8 |
|---|---|---|---|
| Fecal coliform | 1,900,000 | - | 19,000 |
| pH | 6.5 | 4.0 | 7.3 |
| Dissolved Oxygen | 0.0 | 0.0 | 7.9 |
| BOD-5 day | 550 | 22,000 | 25 |
| COD | 1580 | 67,500 | 69.1 |
| Alkalinity | 40 | 0 | 126 |
| Turbidity | 330 | - | 90 |
| Total Solids: | 1778 | 47,810 | 290 |
| Suspended | 124 | 41,358 | 38 |
| Dissolved | 1654 | 6,452 | 252 |
| Organic N | 13 | - | 2.1 |
| Ammonia N | 2.9 | - | .27 |
| Nitrite N | .001 | - | .012 |
| Nitrate N | 1.0 | - | 0.70 |
| Soluble $PO_4$ | 16 | - | 1.4 |
| Total $PO_4$ | 17 | - | 1.8 |
| Hardness | 198 | - | 162 |
| Collection Date | 10/8/68 | 10/9/68 | 10/8/68 |

Table 5. (Continued) Water quality data for stations at Keokuk

| | Iowa Mileage 361.8 | Channel Mile 361.8 | Illinois Mile 361.8 | Des Moines River Mile 361.0 |
|---|---|---|---|---|
| Fecal coliform | 100 | 500 | 300 | 600 |
| pH | 7.6 | 7.7 | 7.7 | 8.9 |
| Dissolved Oxygen | 8.0 | 8.0 | 8.0 | 8.8 |
| BOD-5 day | < 1 | 1 | 1 | 10 |
| COD | 20.3 | 20.3 | 16.2 | 52.6 |
| Alkalinity | 124 | 126 | 126 | 126 |
| Turbidity | 120 | 100 | 100 | 140 |
| Total Solids: | 250 | 238 | 250 | 502 |
| Suspended | 42 | 30 | 38 | 160 |
| Dissolved | 208 | 208 | 212 | 342 |
| Organic N | .72 | .81 | .84 | 3.2 |
| Ammonia N | .09 | .08 | .09 | .01 |
| Nitrite N | .01 | .006 | .009 | .012 |
| Nitrate N | .60 | .70 | .70 | .3 |
| Soluble $PO_4$ | 0.4 | 0.4 | 0.5 | 0.3 |
| Total $PO_4$ | 0.4 | 0.8 | 0.8 | 1.3 |
| Hardness | 160 | 160 | 160 | 254 |
| Collection Date | 10/9/68 | 10/9/68 | 10/9/68 | 10/9/68 |

Table 5. (Continued) Water quality data for stations at Keokuk.

| | Iowa Mile 359.1 | Channel Mile 359.1 | Illinois Mile 359.1 |
|---|---|---|---|
| Fecal coliform | 300 | 300 | 200 |
| pH | 8.2 | 8.2 | 8.0 |
| Dissolved Oxygen | 9.1 | 9.8 | 9.4 |
| BOD-5 day | 3 | 4 | 4 |
| COD | 28.2 | 24.2 | 28.2 |
| Alkalinity | 126 | 124 | 124 |
| Turbidity | 76 | 80 | 94 |
| Total Solids: | 284 | 254 | 254 |
| Suspended | 72 | 44 | 46 |
| Dissolved | 212 | 210 | 208 |
| Organic N | 1.7 | 0.8 | .79 |
| Ammonia N | .11 | 0.11 | .13 |
| Nitrite N | .012 | .011 | .013 |
| Nitrate N | .70 | .60 | .60 |
| Soluble $PO_4$ | .2 | 0.3 | 0.1 |
| Total $PO_4$ | .5 | 0.5 | 0.5 |
| Hardness | 172 | - | 164 |
| Collection Date | 10/10/68 | 10/10/68 | 10/10/68 |

# APPENDIX B

*Chemical and Bacteriological Data collected in the Keokuk Area during February, 1969.

*This information was extracted from a Mississippi River report concerning several areas of the river, which was submitted to the Iowa Water Pollution Control Commission in March, 1969.

# STATE HYGIENIC LABORATORY

Des Moines Branch
405 State Office & Lab Bldg.
East 7th & Court
Des Moines 9, Iowa

| | | | | |
|---|---|---|---|---|
| Town or Station | Keokuk | | | |
| Source | Mississippi | Mile 363.6 | Mile 362.9 - between | Mile 362.6 - 200 yds. |
| Specific Location | Mile 366.1 channel | channel | Bloody Run + STP | below STP, 20 yds. from |
| | above lock + dam 19 | | outfall, 30 yds. from shore | shore. |
| Date Collected | 2/8/69 | 2/8/69 | 2/8/69 | 2/8/69 |
| Date Received | | | | |
| Bottle Number | | | | |
| Bottle Number | | | | |
| Laboratory Number | 3857 | 3852 | 3853 | 3854 |
| Bacterial: Exam. By | | | | |
| C ~~MPN~~ Coliform/100 ml. | | 300 | 3100 | 11,000 |
| | | | | |
| Chemical: (MG/L) Exam. By | | | | |
| Fluoride DMB | | | | |
| Local | | | | |
| Detergents (ABS) | | | | |
| CSCFE | | | | |
| pH Value | | 7.2 | 7.1 | 7.1 |
| Alkalinity P | | None | | |
| T | | 144 | | |
| | | | | |
| Turbidity (Est) | | 28 | 270 | 140 |
| Organic Nitrogen As N | | 0.76 | 1.4 | 2.2 |
| Ammonia Nitrogen As N | | 0.68 | 0.51 | 0.77 |
| Nitrite Nitrogen As N | | 0.025 | 0.030 | 0.037 |
| Nitrate Nitrogen As N | | 1.4 | 1.4 | 1.2 |
| Total Nitrogen As N | | | | |
| Total Solids | | 253 | 431 | 359 |
| Fixed Solids | | 146 | 315 | 224 |
| Volatile Solids | | 107 | 116 | 135 |
| Total Suspended Solids | | 1 | 165 | 100 |
| Fixed Suspended Solids | | 0 | 154 | 62 |
| Volatile Suspended Solids | | 1 | 11 | 38 |
| Total Dissolved Solids | | 252 | 266 | 259 |
| Fixed Dissolved Solids | | 146 | 161 | 162 |
| Volatile Dissolved Solids | | 106 | 105 | 97 |
| Soluble Phosphate ($PO_4$) | | 0.4 | 0.3 | 0.1 |
| Total Phosphate ($PO_4$) | | 0.6 | 0.8 | 0.4 |
| Dissolved Oxygen | 8.3 | 8.5 | 8.9 | 9.2 |
| B. O. D. 5-day 20° C. | | 4 | 11 | 20 |
| | | | | |
| COD | | 18.4 | 43.0 | 24.6 |
| Phenol μg/l | | 10 | | |
| Color (Est) | | 40 | | |
| Total Hardness mg/l | | 180 | | |

Remarks:

Collector Dr. Gakstatter, Roy Jones, Mr. Helms

Report To EES and SCC

R. L. Morris, Ph.D.
JHG Assistant Director & Principal Chemist
19 Mar 69 bj



1341

# STATE HYGIENIC LABORATORY

Des Moines Branch
405 State Office & Lab Bldg.
East 7th & Court
Des Moines 9, Iowa

| | | | | |
|---|---|---|---|---|
| Town or Station | Keokuk | | | |
| Source | Des Moines River | Mississippi River | | |
| Specific Location | 100 yds. from junction with Mississippi | Mile 359.1 channel | | |
| Date Collected | 2/8/69 | 2/8/69 | | |
| Date Received | | | | |
| Bottle Number | | | | |
| Bottle Number | | | | |
| Laboratory Number | 3855 | 3856 | | |
| Bacterial: Exam. By | | | | |
| MF ~~xxxxxx~~ Coliform/100 ml. | 200 | 100 | | |
| Chemical: (MG/L) Exam. By | | | | |
| Fluoride DMB | | | | |
| Local | | | | |
| Detergents (ABS) | | | | |
| CSCFE | | | | |
| pH Value | 7.4 | 7.2 | | |
| Alkalinity P | None | None | | |
| T | 184 | 154 | | |
| Turbidity (Est) | 76 | 45 | | |
| Organic Nitrogen As N | 1.1 | 1.1 | | |
| Ammonia Nitrogen As N | 1.2 | 0.69 | | |
| Nitrite Nitrogen As N | 0.067 | 0.035 | | |
| Nitrate Nitrogen As N | 2.4 | 1.3 | | |
| Total Nitrogen As N | | | | |
| Total Solids | 456 | 297 | | |
| Fixed Solids | 328 | 198 | | |
| Volatile Solids | 128 | 99 | | |
| Total Suspended Solids | 37 | 16 | | |
| Fixed Suspended Solids | 36 | 16 | | |
| Volatile Suspended Solids | 1 | 0 | | |
| Total Dissolved Solids | 419 | 281 | | |
| Fixed Dissolved Solids | 292 | 182 | | |
| Volatile Dissolved Solids | 127 | 99 | | |
| Soluble Phosphate ($PO_4$) | 1.0 | 0.4 | | |
| Total Phosphate ($PO_4$) | 1.2 | 0.6 | | |
| Dissolved Oxygen | 7.45 | 8.65 | | |
| B. O. D. 5-day 20° C. | 4 | .5 | | |
| COD | 16.4 | 18.4 | | |
| Phenol µg/l | 4 | 9 | | |
| Total Hardness mg/l | 320 | 168 | | |

Remarks:

Collector Dr. Gakstatter, Roy Jones, Mr. Helms

Report To EES and SCC

R. L. Morris, Ph.D.
JHG Assistant Director & Principal Chemist
19 Mar 69 bj

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# APPENDIX C

Limnology Status Report to the Iowa Water Pollution Control Commission Delineating Proposed Mississippi River Study Plan for Spring and Summer, 1969.

*The University of Iowa* — *State Hygienic Laboratory*

ENVIRONMENTAL SANITATION
MICROBIOLOGY
SEROLOGY
VIROLOGY

MEDICAL LABORATORY BUILDING • IOWA CITY, IOWA 52240
Telephone—Area 319: 353-5990

12 May 1969

Iowa Water Pollution Control Commission
Mr R J Schliekelman, Technical Secretary

Limnology Status Report: Proposed Mississippi River Study Plan for Spring and Summer, 1969.

After two rather extensive chemical and bacteriological surveys of the Iowa reach of the Mississippi River, it is apparent that biological studies of the bottom fauna are needed to fully evaluate the effects of major Iowa waste discharges to the river. The purpose of the studies proposed for the summer of 1969 would be to fully define the downstream areas which are affected by municipal and industrial waste discharges and determine to what degree the bottom organisms are being affected in these areas. To facilitate this work, only field determinations of dissolved oxygen, temperature, and pH would be made in the study areas during the biological portion of the survey. Extensive collections of water samples would not be made until the biological work was completed and low summer flows were occurring. This would probably be in August or early September.

The biological portion of this study will begin as soon as flooding in the Mississippi subsides to a level approaching normal flows. It is anticipated that this will probably be near the latter part of May and our success in June will be dependent on the spring rain situation. It is important that we get on the river as soon as possible in the spring to complete the biological portion of the survey. Many of the aquatic nymphs emerge (make the transition from aquatic nymph to winged adult) in the late spring and early summer and it is much easier to collect and identify the large, almost mature, nymphs than it is ones which are newly hatched from the egg stage.

A suggested study sequence for the seven major municipal areas would be Clinton, Ft Madison, Keokuk, Muscatine, Dubuque, Davenport, and Burlington. The first five represent the known problem areas on the river and of these five, Dubuque was placed in fifth position because it is already scheduled for secondary treatment. I do feel that Dubuque should be studied so that we can observe the improvement after secondary goes into effect.

For each area it would consist of two phases, one consisting of the study of the numbers and kinds of bottom dwelling organisms and the other consisting of an evaluation of the slime problem below the outfalls. Slime growth is difficult to measure on a quantitative basis because of the problem of sloughing and drifting tufts of slime. I would propose that we look at slimes in a semi-quantitative manner by which we will be able to make relative estimates of quantity, whether or not it is a growth area, and the severity of drifting slime tufts which originated upstream. The same type of apparatus would be used which was tried last fall at Keokuk but which could not be recovered because of river icing. It is essentially half a concrete block, nylon line, a cylinder of chicken wire mesh, and a gallon jug float. The half concrete block serves as an anchor to which the nylon line with float is attached. One wire mesh cylinder would be tied onto the line at mid-depth and another near the bottom. On the first day of the survey in each area, a series of perhaps a dozen or more of these samplers would be placed in the river at various distances downstream from the waste discharges. At least one sampler would be placed above the waste sources and perhaps two would be positioned on the Illinois side of the river. We would leave these samplers in the water for at least three days and after concluding our biological sampling, we would pick up the samplers observing the quantity of slime on the line, wire mesh, and the concrete block. A picture would be taken of each sampler to make a permanent record. The three day period should be sufficient for growth to begin. This would be most readily observed on the concrete block. The line and wire mesh should accumulate drifting Sphaerotilus, if present, and would simulate a fisherman's net.

The biological portion of these surveys would include bottom sampling using the Ponar dredge. This provides a quantitative estimation of the number and kinds of organisms which are present per unit area of river bed. Dredging, however, is known to be a very poor method of making a representative collection of organisms which are present in a given reach of the river so this technique would be supplemented by qualitative collections of the aquatic organisms inhabiting the rocks, limbs, and other debris along the shoreline.

The biological phase of our survey will be as detailed as we have time to make it. I intend to define both the length and breadth of the river which is affected below the waste outfalls. This will require extensive dredging in selected locations. The distance between sampling sites will be dictated by our observations. These stations may be as close as 100 yards or as far apart as one-half mile, depending upon what we observe.

Dredging will also give us the opportunity to look at the composition of the bottom sediments. It is not difficult to distinguish a septic decomposing organic laden sludge from clean silt deposits. Careful notes will be taken of the character of the river bed at each sampling location and the depth will be measured and current velocity estimated.

One of the difficulties we had last fall was determining the exact location of the sampling sites. Although relative positions on the river can be estimated with reasonable accuracy from the navigation charts, it is difficult to estimate distances from the shore, channel markers, etc. This problem could be elimated to a great extent by using a range finder to determine distances from reference points. These are relatively inexpensive items and we are currently investigating this possibility.

I would aniticipate requiring one working week or less in each of the areas to complete these surveys. In this period of time we should be able to do a thorough job. This will require a minimum of two people in the boat and I am hoping that the Mississippi River fisheries biologist, Don Helms, will be able to assist us part of the time. The field work, of course, is only half of the job. After all the sample collections are made and specimens preserved, the organisms must be sorted, counted, and identified. I would estimate that the laboratory phase plus report writing would require a month in addition to the field work.

There is a possibility, if weather conditions are good throughout the summer, that biological surveys could be conducted on both the Mississippi and Missouri Rivers. The Mississippi, however, will have first priority and if time permits, after the Mississippi studies are completed, we will begin work on the Missouri River.

A phenol evaluation program will be started in early May and will continue indefinitely on a monthly basis. Samples will be collected at waterworks intakes on major streams coinciding with other sampling stations with the intent of correlating phenol data and taste and odor evaluation. Studies to determine levels of phenols passing through various types of sewage plants in Iowa are in the planning stage and will supplement and hopefully explain stream data. When preliminary data indicates its feasibility, research attempting to identify source of phenolic compounds will be undertaken. We eventually hope to establish evidence showing taste types and levels to be expected from chlorination of natural substituted phenolics generated by metabolic decay pathways in our environment.

Jack H Gakstatter
Principal Limnologist

R L Morris
Associate Director & Principal Chemist

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