Proceedings of the Iowa Academy of Science

Volume 76 | Annual Issue Article 25

1969

The Effects of Sedimentation on the Water Quality of the Coralville Reservoir, Iowa

Larry R. Mitzner
Iowa State Conservation Commission

Donald B. McDonald
University of Iowa

The Effects of Sedimentation on the Water Quality of the Coralville Reservoir, Iowa

LARRY R. MITZNER[1] AND DONALD B. MCDONALD[2]

Abstract. The Coralville Reservoir is a flood control impoundment located on the Iowa River just upstream from Iowa City. Since being placed in operation in 1958 its capacity at conservation pool level has been reduced nearly 20% by sedimentation. Studies of the reservoir's fishery have been conducted since 1961. Fish population surveys do not indicate a noticeable modification of the fish population due to siltation. A decrease in the total fish population, primarily sport fish, occurring early in 1965, was due to oxygen depletion caused by heavy farm land runoff.

Limnological studies of the Iowa River and the reservoir have been in progress since 1964. These indicate that gradual increases in plankton populations and threshold odor values have occurred in the reservoir and the river below the impoundment. Studies of the biological productivity of the reservoir indicate that maximum production frequently accompanies increased water level and inundation of littoral areas. Thus, increasing reservoir conservation pool level to compensate for loss of capacity due to sedimentation could contribute to water quality problems due to eutrophication.

Sedimentation is a natural process which alters the physical, chemical and biological characteristics of a body of water. The effects may be detrimental or beneficial and the magnitude of such effects vary greatly. Detrimental effects of sedimentation on aquatic life have been listed by Ellis (1937). He summarized the direct effects as follows: 1) bottom fauna organisms are killed by the blanket of silt deposited over them, 2) silt greatly reduces the quantity of food available, 3) spawning grounds and nests are covered by blankets of silt, and 4) the mechanical or abrasive actions of the silt may clog and otherwise impair the gills and respiratory organs of fish and other aquatic life. Among the indirect effects suggested are reduced light penetration and increased oxygen demand.

It is obvious that siltation may significantly affect the fishery and water quality in many impoundments. This paper discusses some of the effects of siltation observed in Coralville Reservoir.

CHARACTERISTICS OF THE CORALVILLE RESERVOIR

Details of the Reservoir and Contributing Area. The Coralville Reservoir is located on the Iowa River several miles upstream from Iowa City, Iowa. It was constructed as a flood control project by the U. S. Army Corps of Engineers and placed in operation in 1958.

[1] Fisheries Biologist, Iowa State Conservation Commission.
[2] Associate Professor, Department of Civil (Environmental) Engineering, University of Iowa.

The drainage area of the Iowa River contributing to the Coralville Reservoir is 3,084 square miles, primarily a rich farming area which, in spite of soil conservation practices, contributes a large amount of sediment to the river and reservoir. Due to the intensive agricultural activities within the reservoir drainage basin, large quantities of nitrates, phosphates and organic matter are carried into the impoundment. These substances, with the extensive shallow water areas present, make the Coralville Reservoir a eutrophic body of water with high biological productivity.

Research on the Reservoir. Weekly studies of chemical and biological conditions in the Coralville Reservoir and the Iowa River have been conducted by the Department of Civil Engineering, University of Iowa, since October 1964. Financial support for this program was provided in part by the U. S. Army Corps of Engineers, Rock Island District. Determinations of dissolved oxygen, pH, carbon dioxide, alkalinity, hardness, iron, ammonia, nitrates, orthophosphates, threshold odor, biochemical oxygen demand, temperature and turbidity, as well as plankton (to genera) and coliform enumerations were made on all samples.

Fish populations have been monitored at the Coralville Reservoir since 1959, but comprehensive surveys were not conducted until 1961. Creel censuses were conducted in 1963, 1964, 1965 and 1967.

Sedimentation Determinations. Surveys were conducted on the Coralville Reservoir basin in October 1958. At that time the reservoir had a maximum capacity of 487,000 acre feet at spillway level (712′ m.s.l.). At conservation pool level (680′ m.s.l.) capacity was 53,750 acre feet. Flood season conservation pool capacity (670′ m.s.l.) was 17,000 acre feet. In August 1968 a resurvey of the Coralville Reservoir by the U. S. Army Corps of Engineers was completed. This indicated that sedimentation had resulted in a reduction in reservoir capacity to 475,000 acre feet at 712′ m.s.l. (2½% reduction); 38,610 acre feet at 680′ m.s.l. (28% reduction) and 7,979 acre feet at 670′ m.s.l. (53% reduction). Observations by the Corps of Engineers indicate that nearly all sediment responsible for the reduction in storage has been deposited below the 680′ m.s.l. level.

Results of Limnological and Fishery Studies

Limnological Studies. It is evident from the limnological studies conducted in the Coralville Reservoir and Iowa River during the past 4 years that the reservoir is eutrophic and supports extensive plankton populations.

Two factors contribute to the high biological productivity of the impoundment. The introduction of large amounts of organic and inorganic substances into the reservoir in runoff from the Iowa

Table 1

Comparison of Average Monthly Chemical and Biological Parameters in the Iowa River Above (A) and Below (B) the Coralville Reservoir October 1966-September 1967

Dates (1966-67)	Orthophosphate ppm		5-Day BOD ppm		Coliforms per 100 ml		Total Plankton per ml		Odor Threshold No.		Turbidity J.T.U.	
	A	B	A	B	A	B	A	B	A	B	A	B
October	0.03	0.03	3.8	3.1	392	1,560	14,565	2,337	3.8	2.7	27	35
November	0.05	0.04	3.5	2.4	518	282	12,520	2,252	3.7	4.1	19	31
December	0.36	0.04	2.6	2.8	53	33	2,457	837	8.2	8.3	10	6
January	1.67	0.74	4.1	2.7	22,644	3,108	872	598	5.2	10.7	35	8
February	1.48	0.71	4.0	5.4	9,860	2,765	512	988	4.5	8.6	20	56
March	1.53	0.51	5.9	4.9	10,890	2,065	964	1,896	6.6	3.6	206	124
April	0.61	0.17	5.7	3.7	1,067	882	31,550	12,135	4.3	3.4	27	41
May	0.25	0.19	6.9	3.6	29,030	1,728	35,374	10,592	3.9	5.1	25	22
June	0.72	0.45	4.1	3.1	89,667	34,433	2,025	3,364	5.1	5.7	116	51
July	0.59	0.35	4.3	3.3	44,083	16,100	17,678	4,695	4.9	7.0	64	35
August	0.24	0.22	6.7	3.7	15,500	2,233	26,177	7,166	—	—	340	28
September	0.23	0.21	3.8	2.3	3,440	3,367	14,250	4,322	3.5	5.3	23	16

River drainage basin provide ample concentrations of phosphorus, nitrogen and other nutrients which contribute to high productivity. Ammonia and nitrate nitrogen and phosphate levels are generally in excess of 0.1 ppm and frequently exceed 1 ppm. Concentrations of organic matter, as measured by biochemical oxygen demand determinations, are also high following periods of runoff and during the winter months may result in reduced dissolved oxygen levels and fish kills within the impoundment. Another factor contributing to the eutrophication of the reservoir is the extensive area of shallow water, which results in high biological productivity in the littoral areas. This productivity is further enhanced by the large areas of terrestrial vegetation that are frequently inundated.

The operation of the Coralville Dam as a flood control structure also appears to influence the limnology of the reservoir. When the reservoir is drawn down to the flood season conservation pool level (670′ m.s.l.) in anticipation of the spring runoff the small amount of storage is quickly altered chemically and biologically by the inflowing river. An example of this occurred in January 1965 when high BOD runoff from frozen ground resulted in low dissolved oxygen levels and subsequent fish kills (McDonald, 1965). Fluctuating water conditions associated with a flood control impoundment seem to affect plankton populations. During spring and summer months increased storage results in large increases in shallow water areas which frequently support large populations of *Anabaena* and other blue-green algae. However, due to high water release rates and subsequent heavy flow-through conditions at this time, these forms did not reach sufficient numbers to affect the open water areas of the reservoir.

Data collected on the Iowa River and Coralville Reservoir since 1964 indicate that the reservoir tends to decrease the nutrient concentration and plankton numbers in the downstream river (Table 1). However, it appears that increases in plankton productivity and decreases in potable water quality, as measured by threshold odor determinations, have occurred in both the river and the reservoir with the most marked changes being observed in the reservoir and the river below the impoundment (Table 2).

Fishery Studies. Fish populations within the reservoir have been influenced by both limnological conditions and management procedures. After impoundment in 1959, fish populations were characteristic of the original river habitat. Species structure at that time consisted of carp, carpsucker, bullhead and buffalo (84%); largemouth bass, channel catfish, crappie, walleye and sunfish (16%).

Stocking of game and predatory species was initiated in 1959 to enhance the sport fishery and reduce the rough fish population. in 1964 the species structure was rough fish (70%) and sport fish

Table 2

Average Plankton and Threshold Odor Values Iowa River and Coralville Reservoir

Iowa River above Reservoir				
Water Year	1964-65	1965-66	1966-67	1967-68
Total Plankton/ml	13,500	4,529	13,245	13,800
Threshold Odor Number	—	3.6	4.9	6.2
Coralville Reservoir (surface)				
Water Year	1964-65	1965-66	1966-67	1967-68
Total Plankton/ml	6,660	4,550	7,100	8,300
Threshold Odor Number	—	3.8	7.4	7.7
Iowa River below Reservoir				
Water Year	1964-65	1965-66	1966-67	1967-68
Total Plankton/ml	3,200	3,413	4,265	5,500
Threshold Odor Number	—	3.2	5.9	11.0

(30%). Early in 1965, a fish kill (Helms 1965) occurred which altered the species complex in favor of rough fish. Ensuing surveys showed a reduction of sport fish to 2.6% of the population.

Extensive remedial stocking in 1965 was followed by an increase of sport fish to 46.9% of the population in 1966. By 1968 rough fish again dominated the species complex; they contributed 64.2% of the population. Creel census studies conducted in 1963, 1964, 1965 and 1967 indicated that less than 10% of the anglers preferred fishing for rough fish (Mitzner 1967); therefore, quality of fishing was measured by: 1) the percent of sport fish in the creel, and 2) the catch of sport fish per man-hour. In 1963 and 1964 relative quality was high; the catch rate was 0.30 and the creel contained 33.3% rough fish. After the 1965 fish kill the catch rate was 0.03 and the percentage of rough fish in the creel increased to 95.4. Quality had increased by 1967, but it has not returned to that realized in 1963.

Discussion

It is difficult to separate the effects of sedimentation from those of other factors on the limnology and fishery of the Coralville Reservoir. It is well known that productivity increases as a lake ages. The introduction of nitrates, phosphates and other inorganic substances by inflowing waters and the buildup of organic sediments occurring from the life processes within the lake result in an increased supply of nutrients for plankton, and ultimately higher aquatic forms. In addition, the deposition of silt results in a reduction of the average depth of the impoundment and a closer associa-

tion between the zones of photosynthesis and decay. Increases in plankton populations and threshold odor values in both the Iowa River and the Coralville Reservoir, since studies were commenced in 1964, indicate a trend towards greater biological productivity.

It is significant that since 1964 increases in plankton productivity and odor have been greater in the reservoir and the river below the impoundment than in the upstream river. This would indicate that eutrophication of the reservoir has been due both to inflowing water quality and environmental changes within the impoundment. Although the reservoir has, to date, generally effected a reduction of nutrients and plankton and improvement of water quality for culinary purposes in the Iowa River, continued eutrophication of the impoundment could reverse this trend and result in reduced water quality.

The effects of sedimentation on reservoir water quality may be further enhanced if changes in reservoir operational procedures are made to compensate for reduced reservoir capacity. At present, reservoir elevation would have to be increased nearly three feet above the 680′ m.s.l. conservation pool in order to achieve the same storage capacity that was available at 680′ m.s.l. in 1958. Increasing the conservation pool to 683′ m.s.l. would result in a substantial increase in shallow water areas. This would, in all probability, contribute to increased productivity and possible water quality deterioration due to algal blooms and accompanying taste and odor problems.

No major effects of sedimentation on fish populations were apparent. Population survey results showed no large differences over a 10-year period. In most cases small fluctuations occurred from year to year, although a large alteration occurred between 1964 and 1966 due to a fish kill during the first 3 months of 1965. This resulted in a decrease in total number of fish with a disproportionate number of sport fish being lost. Repopulation of game species after this incident stabilized the population near original parameters.

There was a positive relationship of species composition between the survey and creel census data. As rough fish increased in the survey a corresponding increase was observed in the creel, indicating a decrease in fishing quality.

The catch per man-hour of sport fish by anglers was positively related to the percentage of sport fish in the survey. A 91% decline of sport fish in the survey agrees with the 91% decrease of sport fish per man-hour in 1965. Decreased angler success in 1965 indicated reduced fishing quality.

Although no 10-year trend has developed with regard to a relationship between sedimentation and species composition or fishing

quality, the fish kill in 1965 was indirectly related to sedimentation. One factor involved in the fish kill was the lack of sufficient water within the impoundment to adequately dilute the organically rich, oxygen poor water from the Iowa River. Thus, reduced reservoir capacity due to sedimentation contributed to the low dissolved oxygen levels and subsequent loss of fish.

Literature Cited

Ellis, M. M. 1936. Erosion silt as a factor in aquatic environments. Ecology 17 (1): 29-42.

Helms, Don. 1965. Coralville Reservoir and Lake MacBride creel census—1965. Iowa Conserv. Comm. Quarterly Biol. Rpts. 17 (3): 44-51.

McDonald, Donald B. & Robert D. Schmickle. 1965. Factors affecting winter fish kills in the Coralville Reservoir, Iowa. Iowa Acad. Sci. Proc. 72:243-247.

Mitzner, Larry R. 1967. Coralville Reservoir and Lake MacBride creel census—1967. Iowa Cons. Comm. Quarterly Biology Repts. 19 (3): 40-45.