Report 130

CONCLUSIONS FROM EXPERIMENTS ON SUGAR PLANT WASTES, RELATING TO POSSIBLE METHODS OF TREATING THESE WASTES AND TO THE DIFFICULTIES IN CLASSIFYING POLLUTIONS AND IN FIXING LEGAL STANDARDS FOR POLLUTED WATERS

For some time the general problems of the relationship between water pollution and fish life have confronted and concerned the Stream Control Commission. The Institute for Fisheries Research has endeavored to supply data leading toward a solution of these problems, and has to date prepared 7 reports on this subject (Nos. 53, 61, 67, 72, 85, 86 and 106). Other reports are forthcoming.

The work done on the effects of sugar plant wastes (Report 106) developed some points of more general application, and these points have been reserved for discussion in this report. The points to be taken up are:

(1) A possible method for the treatment of Steffen's Waste.

(2) A suggestion for the treatment of the other wastes.

(3) The variations in the resistance of fishes to low oxygen.

(4) The incomplete validity of the classification of pollutions into oxygen-consuming and poisonous types.

(5) The difficulties involved in fixing legal standards for degree of pollution permissable in streams.

1. A possible method for the treatment of Steffen's Waste.

In the course of the experiments to determine the effects of Steffen's Waste on fishes, it was incidently discovered that the original rather big toxicity was greatly reduced by the simple process of bubbling air through the liquid. The air was released through a 5/8" Filtros plug, and rose through only 4 inches of water in an aquarium with a surface exposure of 7 3/4" x 13 3/4". More through aeration would probably have accelerated the destruction of the lethal properties of the waste. Even with the more efficient aeration achieved by using the same air outlet in a 2-quart jar, it was found that the oxygen consumption was merely retarded in a 5% solution of this ~~was~~ waste, while with a 10% solution this amount of aeration failed to build the oxygen up to a point higher than 0.5 or 0.6 p.p.m. - so great is oxygen demand of this solution (see experiments B 10-B 16) in Report 106). In the aquaria, a freshly made up 4% solution with one fish, after about an hour contained only 3.65 p.p.m. of oxygen, though aerated the entire hour.

In order to appreciate the difference in the length of time required for the Steffen's Waste solution to kill a fish before and after aeration, we summarize from Report 106 the killing time of 4% and 5% dilutions more or less freshly made up (the 5% experiment performed in two-quart jar; the 4% experiments in aquaria):

Exp.	No.	Aerated?	% Waste	Species	Standard length, mm.	Over all length	Last observed Alive Hr.:Min.	Found dead Hr.:Min.
B10		Yes	5%	Bluegill	67	3.4"	0:40	0:42
B11		No	5%	Pumpkinseed	62	3.1"	-	0:24
C9		Yes	4%	Small-mouth bass	58	3.4"	0:34	0:35
C10		Yes	4%	Pumpkinseed	69	3.4"	-	1:02
C11		No	4%	Small-mouth bass	51	2.5"	0:12	0:24
C12		No	4%	Pumpkinseed	55	2.7"	-	1:22*
C13		No	4%	Rock bass	35	1.9"	0:40	3:10*
C14		No	4%	Hybrid sunfish.	ab. 105	ab. 5"	4:26	5:37

*Just died.

We may now show the results obtained in the standard aquaria (using 5000 cc., giving a depth of roughly 4" and a surface exposure of 7 3/4" x 13 3/4", by using what was 4% Steffen's Waste, but now weakened in whatever may be in death-causing properties, by being aerated for many hours. The experiments are a continuation of those listed in Report 106. In all four experiments aeration was continued through the experiment.

Experiment C 17: rock bass which had survived Exp. A 3 (34 mm. standard length, 1.7 inches over all). This solution had killed a pumpkinseed sunfish in 1 hr.: 2 min. (exp. C 10), but had then been allowed to stand with aeration a an additional period (21 hr.: 29 min.); started 11:20 A.M., November 19.

Hr.:Min.		Hr.:Min.	
0:40	Normal	85:00	Normal
3:10	"	93:00	"
6:40	"	103:00	"
11:25	"	117:00	"
21:00	"	120:40	"
32:10	"	140:50	Dead
45:10	" ; oxygen, 2.65 p.p.m.		

Experiment C 18: hybrid sunfish which had been serving as one of controls for C-series (about 5 inches over all). This fish added to Exp. C 17 at 8:45 A.M., November 20, or after solution had been aerated 43 hr.: 56 min.

Hr.:Min.		Hr.:Min.	
4:15	Normal	71:35	Normal
10:45	"	95:35	Normal
23:45	" ; oxygen 2.65 p.p.m.	119:25	" ; experiment ended.
63:35	"		

Experiment C 19: black-nosed dace (69 mm. standard length; 3.2 inches over all). This fish added to Exp. C 17 after it had run just 85 hours; therefore after the solution had been aerated for 107 hr.:31 min. It should be recalled that the dace are more delicate than sunfishes.

Hr.:Min.		Hr.:Min.	
8:00	Normal	18:00	Dead

Experiment C 20: green sunfish (81 mm. standard length; 4.0 inches over all). This fish added to Exp. C 17 after it had run just 85 hours; therefore after the solution had been aerated for 107 hrs.:31 min.

Hr.:Min.		Hr.:Min.	
8:00	Normal	32:00	On side; breathing hard
18:00	"	33:00	Dead

Clearly much of the toxicity of dilutions of Steffen's Waste is greatly reduced by bubbling air through it one to several days. If no reasonably economic way of consuming Steffen's Waste as a by-product is developed, we would suggest that some consideration be given to the possibility of temporarily storing and aerating it before allowing it to discharge into natural waters. Of course, much further experimentation would be called for, especially in the aeration of full strength of Steffen's Waste, or strong solutions.

2. A suggestion for the treatment of the other wastes.

While the experiments have shown that the other wastes, which the sugar plants give off in much larger quantity, are not nearly so poisonous as Steffen's Waste, yet they must play a large role in depleting streams of their oxygen. They make up in total quantity whatever they may lack in deleterious quality.

Ever since my studies of sugar plant wastes in 1921, I have felt convinced that some way could be devised to retain these wastes within the plant, using the water in a circulating system. The cost of removing the suspended matter by sedimentation, filtration, centrifuging or other means, would very likely be offset by the great decrease in the heating bill, for the coal waste in discarding hundreds of thousands of gallons of warmed water after one use must be great. Some thought might be given to the possibility of thus concentrating to a savable point the weak solution of sugar which is now lost.

3. The variations in resistance of fish to low oxygen.

In the experiments with sugar plant wastes it was found that the amount of dissolved oxygen in the pollution samples was not at all closely correlated with whether the fish died or not. The data are summarized in Table I. An examination of this Table will show thate the fish often died in the presence of what we would ordinarily consider sufficient oxygen, whereas others lived for about three days in water having less than 0.5 p.p.m. of oxygen (expecially experiments C 4 and C 5).

TABLE I.

Exp. No.	Kind of Waste	% Waste	Aerated?	Species of fish	Oxygen p.p.m.	Time of Analysis	Last observed alive Hr.:Min.	Found dead Hr.:Min.
A 2	Control	0	No.	Long-eared sunfish	1.90	2:52	6:36	13:45
A 5	Beet	1	Yes	Large-mouth bass	5.85	61:35	52:00	61:35
A 6	Beet	1	No	" " "	0.60	2:34	1:47	2:34
A 7	Beet	10	Yes	Perch	5.40	28:52	26:52	28:52
A 8	Beet	10	No	Perch	0:80	5:49	4:03	5:49
A 9	Beet	50	Yes	Pumpkinseed	5:90	98:10	85:10	98:10
A10	Beet	50	No	"	0.35	2:66	2:43	2:51
A11	Beet	100	Yes	"	3.15	4:10	3:25	4:10
B 4	Steffen	0.1	No	Rainbow darter	1. 50	4:25	4:00	4:25
B 7	"	2	Yes	Perch	4.90	36:03	27:58	36:03
B10	"	5	Yes	Bluegill	3.90	0:42	0:40	0:42
B11	"	5	No	Pumpkinseed	2.90	0:24	-	0:24
B12	"	10	Yes	"	0.50	0:20	0:18	0:20
B13	"	10	Yes	Rock bass	0.50	0:26	0:20	0:26
B14	"	10	Yes	Stickleback	0:60	0:57	0:47	0:57
B15	"	10	No	Pumpkinseed	0:50	0:14	0:11	0:14
B16	"	10	No	Bluegill	0.50	0:23	0:22	0:23
C 1	Control	0	Yes	Hybrid sunfish	6.45	29:40	Did not die	
C 2	"	0	Yes	" "	6.50	29:40	" " "	
C 3	"	0	Yes	" "	6.65	29:40	" " "	
C 4	"	0	No	" "	0.40	46:00	" " "	
					0.33	46:00	" " "	
					0.25	70:10	" " "	
C 5	"	0	No	" "	0.40	24:15	" " "	
					0.40	29:40	" " "	
					0.47	46:00	" " "	
					0.40	70:10	" " "	
C 6	"	0	No	" "	0.70	29:40	" " "	
					1.68	46:00	" " "	
					2.50	70:10	" " "	
C 7	Steffen	2	Yes	" "	5.85	29:40	" " "	
					2.50	70:10	" " "	
C 8	"	2	No	" "	0.00	21:55	13:40	21:45
					0.00	23:45	"	"
C 9	"	4	Yes	Small-mouth bass	2.35	0:36	0:34	0:36
C10	"	4	Yes	Pumpkinseed	3.65	1:02	-	1:02
C11	"	4	No	Small-mouth bass	2.35	0:24	0:12	0:24
C12	"	4	No	Pumpkinseed	3.15	1:22	-	1:22
C14	"	4	No	Hybrid sunfish	0.00	5:37	4:26	5:37
C15	"	6	Yes	" "	1.45	0:55	0:48	0:55
C16	"	6	No	" "	2.00	0:55	0:48	0:55
C17	"	4	Yes	Rock bass	2.65	45:10	120:40	140:50
C18	"	4	Yes	Hybrid sunfish	2.65	23:45	Did not die	

The dissolved oxygen concentrations at which the fishes died and at which they lived, as given in Table I, varied as follows:

Fishes died Oxygene analyses, p.p.m.		Fishes lived Oxygen analyses, p.p.m.	
0.00	1.90	0.25	2.50
0.00	2.00	0.33	2.50
0.00	2.35	0.40	2.65
0.35	2.65	0.40	5.85
0.50	2.90	0.40	6.40
0.50	3.15	0.40	6.45
0.50	3.15	0.47	6.50
0.50	3.65	0.70	6.65
0.60	3.90	1.68	
0.60	4.90		
0.80	5.40		
1.45	5.85		
1.50	5.90		

(4) <u>The incomplete validity of the classification of pollutions into oxygen-consuming and poisonous types.</u>

We have for years considered the sugar plant wastes, including Steffen's Waste, as of the oxygen-consuming character, as opposed to the poisonous types of many industrial wastes. We knew, of course, that the lethal properties of low oxygen are accentuated by an increase in the dissolved carbon dioxide. We had not before realized, however, how closely related are the lethal properties of low oxygen and the presence and kind of oxygen-consuming wastes in the water. In the presence of Steffen's Waste our fishes died when the oxygen varied from 0 to about 6 parts per million. Yet in the absence of these wastes, using a good water well conditioned for fish life, sunfishes lived about 3 days in water having less than 0.5 p.p.m. of oxygen.

It becomes clearly apparent, that a distinction of Michigan pollutions into oxygen-consuming and toxic types is artificial and probably of no practical use, and should therefore be abandoned (by those of us who have adopted such a classification). This conclusion is confirmed by other data and experience which we are accumulating, both in natural and in polluted waters.

5. <u>The difficulties involved in fixing legal standards for degree of pollution permissable in streams.</u>

The killing of fish in water having a dissolved oxygen content of 3 to 6 parts per million, on account of the presence of a waste which is essentially of the oxygen-consuming properties, makes it difficult to give advice for the fixing of a legal standard of dissolved oxygen permissable for polluted waters. Clearly, experiments to determine such a suitable yard-stick should be run in the presence of actual pollution materials. Probably every different type of pollution will be found to kill fishes at its own specific dissolved oxygen point.

Certainly the point of 4.0 parts per million of dissolved oxygen, which has been considered as a safe value for all streams under all conditions, is not confirmed by the experiments cited in this report and Report 106. To judge by our present evidence, a minimum oxygen value of 6.0 p.p.m. would be none too low to hold as needed to consider a stream fit with any degree of assurance for fish life.

The variability of the lethal point of dissolved oxygen would apparently call either for a relatively high value to be fixed as a legally acceptable one, or for separate tests of either a chemical or a physiological nature to bemade on each polluted water under consideration.

This report has been prepared for the consideration of the Stream Control Commission and the Department of Conservation by the undersigned.

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