April 13, 1932

Report No. 134

REPORT ON TOXICITY OF STEFFEN'S WASTE AFTER PONDING

This report is a follow-up on Reports No. 106 and 130. It deals with the toxicity of Steffen's waste after this has been ponded for a considerable number of weeks.

The sample of waste used in these experiments was delivered to the Institute for Fisheries Research at 1:45 P.M. on March 4, 1932, by T. J. Powers of the Stream Control Commission. The statements of Mr. Powers and the label on the bottle indicated that the sample had been taken that morning at 11 A.M. from the Steffen's pond at waste pump, at the Blissfield plant of the Great Lakes Sugar Co. The pond was said to be receiving some seepage from the lime cake ponds, and the temperature of the ponded waste was given as 5° C. The first series of experiments, using 2 liter solutions, were started almost immediately, at 2:10 P.M. on March 4. The second series, using 5 liter solutions were started at 10:30 A.M. on March 6. In the meantime the sample of waste had been kept stoppered, and cooled by a cold water jacket.

A comparison of the results presented below (Tables 4 to 9) with those obtained from fresh, unponded Steffen's waste (Report 106) discloses no clear-cut differences. We attribute the failure of the waste to become self-purified in this time interval to the fact that it was not diluted, nor aerated. Steffen's waste when ponded obviously undergoes anaerobic decomposition, on account of its extremely high oxygen demand. The pond itself is reputed to have given off a pronounced odor, and the sample of the ponded waste had a very strong odor—a mixture of sugary sweetness and

unpleasant putridity. The odor was apparent in 5% and 10% solutions, not completely disappearing until the toxicity had been about destroyed by aeration.

The sample differed in other respects than odor from fresh Steffen's waste, indicating that it had undergone considerable change. It was no longer of a bright orange amber color, but was rather a dirty yellowish gray. On shaking it produced suds-like foam, but not so strikingly as the fresh waste does. On aeration the solution, unlike the fresh waste, did not precipitate lime. Mr. Milton B. Adams informs me that the ponded waste had lost the strong caustic alkalinity of the fresh waste. Since the toxicity remains, this may indicate that the caustic alkalinity is not the cause of the toxicity of the fresh waste. On the other hand, the toxicity of the fresh waste may have been due, so far as we can say to the caustic alkalinity, and the toxicity of the ponded wastes to some other chemical perhaps to products of anaerobic decomposition.

The possibility that the toxicity of the fresh and ponded wastes, though roughly similar may be due to different causes, finds some support in the way the fish died. In dilutions of the ponded waste, the fish usually remained apparently normal for a long period; then a few minutes later would be dead. The period of turning on the side or rolling or dashing was usually very short. Death occurred with violent twitchings and often in an opisthotonic rigor suggesting that the toxic principle was acting on the central nervous system.

The reported lack of any fish deaths in the river during the period when the ponded Steffen's waste was being released was taken by some to indicate that the toxicity of the waste was destroyed, which we have found not to be true. The factors which permitted the fish to live we would assume to be rather due to the high water level and low water temperature of this period.

The greater resistance of fish to the solutions of the waste when cooler is shown by the first results obtained with the 5% and 10% wastes in the two-liter experiments. The solutions were made up with water at 14.5°. In the 5% experiments

(Table 5) both of the fish, and in the 10% experiments (Table 7) one of the fish first introduced, and hence enjoying cooler water, lived longer than did the same species after the water temperature had risen 18.5°C.

The lack of a close correlation between low dissolved oxygen value and ~~between low dissolved oxygen value~~ and the killing of the fish characterized the experiments with the ponded waste as well as those using fresh waste. When the waste was weak (2% solution) the fish did not die until the oxygen was low, but when the waste was strong (5% to 25% solutions) the fish died when the oxygen was high (2.9 to 6.2 pp.m.). The data are given in Table I.

Table I. Dissolved oxygen analyses made during experiments with ponded Steffen's waste.

Exp. no.	% waste	Aerated?	Species of fish	Oxygen p.p.m.	Time of analysis Hr:Min.	Last seen alive Hr:Min.	Found dead Hr:Min.
2a	2	No	Blunt-nosed minnow	0.85	23:05	22:20	23:05
2b	2	"	Golden shiner	"	"	194:20	198:05
1a	0	"	Blunt-nosed minnow	1.8	52:35	187:20	194:20
1b	0	"	Golden shiner	"	"	"	"
6c	10	"	" "	2.9	0:48	0:40	0:48
"	10	"	" "	"	"	2:45	11:00
10h	25	Yes	Blunt-nosed minnow	3.0	0:30	— —	0:30
10g	25	"	Golden shiner	5.2	0:40	— —	0:40
10g	25	"	" "	"	"	0:40	0:48
7c	10	"	Blunt-nosed minnow	5.3	1:04	0:16	1:04
8h	10	"	Golden shiner	5.8	0:30	0:30	0:40
5d	5	"	" "	6.2	0:26	2:10	2:11

The toxicity of the ponded waste was destroyed by aeration, very much as that of the fresh waste was. This is suggested by the data given in Table 5 and proved in that given in Tables 6 and 8. It is of particular interest, especially from the point of view of the possible use of compressed-air aeration in purifying the waste, that the toxicity of the 5% solution was removed in less than half the time required

to remove the poisonous properties of the 10% solution. The approximate figures, given in Table 2, are taken from the data in Tables 6 and 8.

Table 2. Time required for reduction and elimination of toxicity of Steffen's waste solutions, by means of aeration.

	Time required, using 5% solution	Time required, using 10% solution
Marked reduction noted:	less than 2 days	9 days
Toxicity largely destroyed:	less than 2 days	10 days
Toxicity still obvious:	4 days	16 days
Toxicity apparently gone:	9 days	?

PRESENTATION OF DATA

Table 3. Control (no waste). Not aerated; 2 liters of filtered water in small aquarium; temperature 14.5° C. at start, gradually increasing to 18.5°C.

Blunt-nosed minnow		Golden shiner	
Hr.:Min.		Hr.:Min.	
44:03	Normal	18:05	Approximately normal
52:30	Gasping rather wildly at surface; oxygen 1.8 p.p.m.	44:03	Same
66:15	Approximately normal	66:15	Same
187:20	Still alive	187:20	Same
194:20	Dead	194:20	Dead (death probably due to lack of oxygen)

Table 4. 2% waste. Otherwise as in Table 3.

Blunt-nosed minnow		Golden shiner	
Hr.:Min.		Hr.:Min.	
9:50	About normal	23:25	Approximately normal
18:05	Same	66:15	Same
22:20	Lapping at surface	142:50	Very weak and thin
23:05	Dead; dissolved oxygen only 0.85 p.p.m.	194:20	Same
		198:05	Dead

Table 5. 5% waste. Otherwise as in Table 3.

Exp. no.	Species	Aerated?	Length of previous standing without aeration. Hr.:Min.	Length of previous aeration Hr.:Min.	Time last seen alive Hr.,:Min.	Time found dead Hr.:Min.
3a	Blunt-nosed minnow	No	0:00	0:00	9:50	18:05
3b	Golden shiner	No	0:00	0:00	9:50	18:05
4a	Blunt-nosed minnow	Yes	18:10	0:00	1:55	2:20
4b	Golden shiner	Yes	18:10	0:00	1:55	2:20
4c	Blunt-nosed minnow	Yes	18:10	5:56	3:39	19:57
4d	Golden shiner	Yes	18:10	5:56	46:29	46:44
4e	Golden shiner	Yes	18:10	48:05	7:20	7:35

Table 6. 5% waste. Solution made up to 6 liters in a small aquarium with filtered water at 18.5°C. Aerated for 10 minutes before and throughout experiments.

Exp. no.	Species	Length of previous aeration Hr.:Min.	Time last seen alive Hr.:Min.	Time found dead Hr.:Min.
5a	Golden shiner	0:10	1:42	1:43
5b	" "	2:15	1:52	2:45
5c	" "	5:02	0:58	1:11
5d	" "	6:14	2:10	2:11
5e	" "	23:20	1:15	1:25
5f	" "	26:50	1:45	1:55
5g	" "	45:50	36:40	37:40*
5h	" "	93:50	33:15	48:20
5i	Blunt-nosed minnow**	215:10	238:35	- -

* Jumped out of tank

** Usually at least as sensitive as golden shiner.

Table 7. 10% waste. Otherwise as in Table 3.

Exp. no.	Species	Aerated?	Length of previous standing without aeration Hr.:Min.	Length of previous duration Hr.:Min.	Time last seen alive Hr.:Min.	Time found dead Hr.:Min.
6a	Blunt-nosed minnow	No	0:00	0:00	4:35	7:00
6b	Golden shiner	"	0:00	0:00	2:15	2:30
6c	Golden shiner	"	7:05	0:00	0:40	0:48
	Golden shiner	"	7:05	0:00	2:45	11:00
7a	Blunt-nosed minnow	Yes	18:10	0:00	0:30	1:25
7b	Golden shiner	"	18:10	0:00	2:20	2:45
7c	Blunt-nosed minnow	"	18:10	5:56	0:16	1:04
7d	Golden shiner	"	18:10	5:56	0:16	1:04
7e	Blunt-nosed minnow	"	18:10	7:05	0:29	0:30
7f	Golden shiner	"	18:10	7:05	0:30	1:15

Table 8. 10% waste. Solution made up to 6 liters in a small aquarium, with filtered water at 18.5°C. Aerated for 10 minutes before and throughout experiments.

Exp. no.	Species	Length of previous aeration Hr.:Min.	Time last seen alive Hr.:Min.	Time found dead Hr.:Min.
8a	Golden shiner	0:10	0:18	0:50
8b	" "	1:00	1:13	1:14
8c	" "	2:15	0:26	0:36
8d	" "	2:51	0:39	0:51
8e	" "	3:42	0:25	1:18
8f	" "	5:02	0:23	0:37
8g	" "	5:53	0:31	0:44
8h	" "	7:10	0:30	0:40
8i	" "	23:20	0:35	0:45
8j	" "	26:50	0:35	0:45
8k	" "	45:50	0:30	0:40
8l	" "	69:35	0:18	0:30
8m	" "	93:50	0:25	0:40
8n	" "	118:45	0:05	0:58
8o	" "	142:10	0:34	0:50
8p	" "	190:07	2:13	2:13
8q	" "	214:18	- -	0:47*
8r	Blunt-nosed minnow***	215:10	2:23	3:20
8s	" "	244:45	- -	17:05**
8t	" "	262:10	13:20	29:20
8u	Steel-colored shiner***	385:20	54:00	69:25

* Fish was weak to begin with.

** Dead several hours.

*** Usually at least as sensitive as golden shiner.

Table 9. 25% waste. Otherwise as in Table 3.

Exp. no.	Species	Aerated?	Length of previous standing without aeration Hr.:Min.	Length of previous aeration Hr.:Min.	Time last seen alive Hr.:Min.	Time found dead Hr.:Min.
9a	Blunt-nosed minnow	No	0:00	0:00	–	0:38
9b	Golden shiner	"	0:00	0:00	0:38	0:42
10a	Blunt-nosed minnow	Yes	0:55	0:05	0:20	0:25
10b	Golden shiner	"	0:55	0:05	0:25	0:37
10c	Blunt-nosed minnow	"	0:55	0:45	0:14	0:17
10d	Golden shiner	"	0:55	0:45	0:25	0:35
10e	Blunt-nosed minnow	"	0:55	3:40	–	2:25
10f	Golden shiner	"	0:55	3:40	–	2:29
10g	Golden shiner	"	0:55	6:10	–	6:30
	Golden shiner	"	0:55	6:10	0:40	0:48
10h	Blunt-nosed minnow	"	0:55	17:15	–	0:30
10i	Golden shiner	"	0:55	17:15	–	0:30