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Report 194

EFFECT ON FISH LIFE OF EFFLUENT FROM NEW SEWAGE TREATMENT PLANT AT DEARBORN, MICHIGAN

Some time ago Mr. Milton P. Adams, in charge of the Michigan Stream Control Commission, asked if we could run some experiments to determine the effect on fish life of the effluent from a new type of sewage treatment plant. We understand that this plant is operating at Dearborn, that it is cheaper to install than treatment plants of other types, that it removes a fairly high percentage of suspended solids in a filter-bed of magnetite sand, and that it yields an effluent which on chemical tests seem to stand between those obtained from primary and from secondary treatment (we have not tested these points ourselves).

Since a new process of treatment is involved, it seemed desirable to determine the effect of the effluent of the new plant on fish life. The Institute offerred to run some experiments to obtain data bearing on this problem. As a consequence of this agreement, a 5-gallon sample in a carboy was brought to Ann Arbor about 10 P.M. February 23, by representatives of the Stream Control Commission. The carboy was left outside, so the liquid was held undiluted at a temperature not far above freezing. The experiments were begun the next day.

Experiment 1

Two dilutions each of 0% (controls), 10%, 25%, 33 1/3% and 66 2/3% were made up about 10 A.M., using enough of our filtered and circulating aquarium water to make up one liter of solution, in two-quart fruit jars. One complete set was aerated by compressed air. A second complete set was allowed to stand without any aeration except what entered through the limited surface. The solutions were all brought

to the room temperature, about 25° C, before the fish were added. Temperatures during the experiments varied from 22°C to 26°C in the different jars. The fish used were all half-grown guppies (Lebistes reticulatus). This is a rather resistant tropical aquarium fish. The experiments were all started at 10:35 A.M. February 24. A summary of the results follow:

0% sewage (control), ~~not~~ aerated; two fish.

Hr.:Min.
12:50 Remaining entirely normal
21:15 Same
27:45 Still normal; experiment ended

0% sewage (control), not aerated; two fish.

Hr.:Min.
12:50 Remaining entirely normal
21:15 Same
27:45 Still normal; experiment ended.

10% sewage; aerated; two fish

Hr.:Min.
12:50 Remaining entirely normal
21:15 Same
27:45 Still normal; experiment ended.

10% sewage, not aerated; two fish.

Hr1:Min.
12:50 Remaining entirely normal
21:15 Same
27:45 Still normal; experiment ended.

25% sewage, aerated; two fish

Hr.:Min.
12:50 Remaining entirely normal
21:15 Same
27:45 Still normal; experiment ended.

25% sewage, not aerated; two fish.

Hr.:Min.
11:30 Remaining normal
12:50 At surface, but otherwise normal
21:15 Same
27:45 Apparently wholly normal; experiment ended.

33 1/3% sewage, aerated; two fish

Hr.:Min.
7:08 Apparently quite normal

8:50 A bit sluggish
14:40 No further weakening
21:15 Same
27:45 Seemingly normal; experiment ended

33 1/3% sewage, not aerated; two fish

Hr.:Min.
7:08 Apparently quite normal
8:50 A bit sluggish
11:30 No change
12:50 At surface, but otherwise normal
Hr.:Min.
21:15 No change
27:45 Apparently normal; experiment ended

50% sewage, aerated for first 27 hr.: 45 min.; two fish.

Hr.:Min.
7:08 Apparently quite normal
8:50 A bit sluggish
14:40 No further weakening
21:15 Same
Hr.:Min.
27:45 Seemingly about normal; aeration discontinued
30:00 O.K.
35:25 O.K.
38:25 O.K., temperature 25°C.
47:25 O.K.; temperature 24°C.; experiment ended.

50% sewage, not aerated; three fish

Hr.:Min.
7:08 Apparently quite normal
8:50 A bit sluggish
11:30 No change
12:50 At surface, but otherwise normal
21:15 No change
27:45 Apparently normal
Hr.:Min.
30:00 O.K.
35:25 O.K.; temperature 26° C.
38:25 O.K.; have been eating sewage particles
47:45 O.K.; temperature 24° C; experiment ended

66 2/3% sewage, aerated; two fish.

Hr.:Min.
0:03 Wild, twisting around, head down
0:15 Much quieter, apparently adjusted
7:08 Apparently quite normal
8:50 A bit sluggish
14:40 No further weakening
21:15 Same
Hr.:Min.
27:45 Seemingly about normal; aeration discontinued
30:00 O.K.; temperature 22° C.
35:25 O.K.— temperature 23° C.
38:25 O.K.
47:45 O.K.; temperature 24°C.; experiment ended.

66 2/3% sewage, not aerated; three fish.

Hr.:Min.
0:03 Wild, twisting around, head down
0:15 Much quieter, apparently adjusted
7:08 Apparently quite normal
8:50 A bit sluggish
11:30 No change
12:50 At surface, but otherwise normal
Hr.:Min.
21:15 No change
27:45 Apparently normal
30:00 O.K.; temperature 23° C.
35:25 O.K.; temperature 24° C.
38:25 O.K.
47:45 O.K.; temperature 24°C; experiment ended.

Conclusion from Experiment 1.— Solutions of the sewage plant effluent as strong

as 1 part to two or even one part of water, even as strong as 2 parts of sewage to one of water, failed to kill any of the half-grown guppies, when kept under summer conditions. It is true that the guppy is a very resistant fish and very thoroughly acclimated to aquarium conditions, but if there had been any particularly toxic feature about the effluent, some of the fish would certainly have been killed, or would have died subsequently. The toxicity of this sewage effluent must be very low.

Experiment 2

In this experiment native fish were used, namely minnows and shiners from a creek near Ann Arbor. These were almost entirely blunt-nosed minnows (Hyborhynchus notatus) and common shiners (Notropis cormutus). As the two species showed no apparently differences in resistance, they are not separately considered. Three fish were put in each jar. These fish were seined about 3:00 P.M. February 24, in water not far above freezing. The dilutions were made up as for Experiment 1 in two-quart jars, just before the experiments were started at 11:15 P.M. February 24. All solutions were given a few minutes aeration after the fish were added. The creek water in which the fish were being kept was now up to 6°C, while the sewage sample had cooled to 9°C. After mixing up the sewage with the aquarium water at about 24°C. the solutions were all cooled to 14° or 14.5°C, the temperature at the time of the water which was flowing around the jars. The water jacket and the water in the jars soon dropped to 12°C. and remained at that point until the flow of water in the jacket was stopped at 34 hr.: 45 min., after which time the temperature gradually rose to about 25° C. In this way, the creek fish, taken in water nearly freezing in temperature were tested as to their resistance to the sewage plant effluent at a spring temperature, and then were gradually acclimated to summer temperatures while still in the solutions.

Table I

Summary of temperatures in Exp. 2.

Hr.:Min.
0:00—14.0 to 14.5° C.
8:35 (and no doubt earlier)—12° C.
17:20—about 12° C.

Hr.:Min.	Hr.:Min.
34:45—12° C.	56:35—23.5° to 24.5°C.
36:30—About 15°C.	59:15—23.5°C.
39:05—18.5° to 20.0°C.	63:15—23.6° to 25.0° C.
41:05—20.5° to 21.5° C.	67:55—24.5° to 25.0o C.
41:35—20.5 to 22° C.	69:25—24.0° to 25.3° C.
47:05—All near 24° C.	80:45—23.6° to 25.0° C.

These temperatures and times should be considered in interpreting the results of Experiment 2, which are now tabulated (Table II)

Table II

Summary of Results of Experiment 2

The figures refer to hours and minutes after beginning the experiment.

Strength of Solution in Terms of Sewage	All 3 fish last seen alive	First fish found dead	Other fish last seen alive	Second fish found dead	Third fish last seen alive	Third fish found dead
0% aerated (control)	47:05 [1]	56:35	109:45	129:45	129:45	130:45 [2]
0% not aerated (control)	153:55	157:30	157:30	177:30	177:30	-
10% aerated	64:00	67:55	177:30	-	-	-
10% not aerated	86:45	109:45	109:45	129:45 [3]	129:45	130:45
25% aerated	64:00	67:55	137:45	138:45	153:25	153:55
25% not aerated	80:45	81:45	81:45	83:20	83:20	83:45
33 1/3% aerated	177:30 [4]	#	-	-	-	-
33 1/3% not aerated	47:05 [5]	56:35	-	56:35 [6]	56:35	59:15
50% aerated	56:35	59:15	63:15	64:00	177:30	-
50% not aerated	157:30	177:30	177:30	-	-	-
66 2/3% aerated	41:35	47:05 [7]	69:25 [8]	80:45	80:45	81:45
66 2/3% not aerated	56:35 [9]	59:15	64:00	67:55	84:45	86:45
100% aerated	47:05 [10]	-	-	-	-	56:35
100% not aerated	41:35 [11]	47:05	-	47:05 [12]	47:05	56:35

[1] One twitching
[2] A fourth control, in aerated jar, was alive at 137:45, but dead at 138:45.
[3] Remaining fish dying.
[4] On of the three in this jar was removed alive at 47:05.
[5] One nearly dead; two weak.
[6] Remaining fish wild.
[7] Remaining two fish nervous.
[8] One was weakening at 63:15; both wild at 67:55 and 69:15.
[9] For long time had been lapping at surface.
[10] For some time had been gasping and twisting.
[11] Sluggish from first.
[12] Remaining fish lapping.

Conclusion from Experiment 2.—This experiment, even more than the previous one, shows that there can be nothing very toxic about the Dearborn sewage effluent tested. All the minnows and shiners, which are relatively delicate species, lived for about a day and a half in solutions grading from 0% to 100% sewage, whether aerated or not, and spring temperature conditions (about 12° C.). Even when the temperature was then allowed to rise to summer conditions, the mortality was slow in appearing. In 100% sewage the total life was about 2 days; in two-thirds sewage, 2 to 3 1/2 days; in 50% sewage, 2 1/2 to more than 7 days; in one-third sewage, 2 to more than 7 days.

Experiment 3

This was a mass experiment, with control. These were made up 27 to 32 hours after the fish had been caught, and about two days after the sewage sample was collected. The fish now crowded in the collecting cans had become gradually warmed to 21° C. The fish were divided among two bushel cans, containing 12 gallons each. One contained aquarium water only (cooled down to 20.5° C. for the start), while the other contained a 50-50 mixture of that water and the sewage (the solution warmed to 21° at first). Both lots were aerated. About 200 fish were put in each container.

0% sewage (control); when this experiment was started on February 25 at 10:35 P.M., a considerable number of the minnows in the collecting can were dying and all were lapping at the surface, and the water smelled foul.

Hr.:Min.
1:40 About 12 dying fish removed.
2:25 About 20 sick and 2 dead fish, removed.
11:35 About one-half dead.
13:00 About three-fourths dead.

50% sewage; when this experiment was started at 5:40 P.M., February 25, the fish in the collecting can were in better condition.

Hr.:Min.
4:20 All normal, except one small shiner.
6:35 Only one shiner dead and a few others wild.
7:20 A few shiners appear weak.
16:20 About one-half dead.
17:45 About three-fourths dead.

Conclusion from Experiment 3.—The fact that only one fish out of about 200 were killed and only a few more were clearly weakened after being kept at summer temperature (23.5° C.) in the 50% sewage for more than 7 hours is further indication that this sewage effluent is not particularly toxic. The high losses sustained later were paralleled (even exceeded) in the control. Unfortunately the control was not very accurate, as the fish when put into it were already in distress. The large losses, similar to large losses often experienced in minnow liveboxes, were probably due to overcrowding, and to having been warmed up too fast.

Experiment 4

In this experiment, started 10:50 P.M. February 25, part of the jars and solutions used in Exp. 1 were again employed. These had stood after the completion of that experiment for 8 1/2 hours, without aeration, at a temperature of 22° to 23° C. Original strengths of solution were 0% to 33 1/3%. One set of the series had been aerated for the period of experiment 1 (27 hr.: 45 min.), while the other half had not been aerated. None were aerated during Experiment 4.

Later (12:31 to 1:10 A.M. February 26) the experiment was repeated, again using minnows and shiners from the stock used in Experiments 2 and 3, under similar conditions. The experiment was also repeated, beginning 12:10 A.M., February 26, with guppies (Lebistes reticulatus), of the same stock used in Experiment 1. The second lot of minnows and the guppies were in the jars together.

Conclusion from Experiment 4.—It is clear from Experiment 4 that minnows and shiners can be very quickly killed in 10 to 33 1/3% solutions of the sewage effluent under consideration, after it has stood for several hours without aeration. Under the same conditions the guppies lived merrily on, showing only slight discomfort by swimming at the surface. The results with the minnows and shiners are contradictory to those of Experiment 2. The lethal results obtained in Exp. 4 but not obtained in Experiment 2 were probably due to the weakening of the fish used by longer overcrowding or by a less gradual change in temperature. That the

Table III

Summary of Results of Experiment 4.

Figures refer to hours and minutes

Strength of solution in terms of sewage		No. of fish used	Time aerated before start of Exp.	Time without air before start	All fish last seen alive	First fish found dead	Other fish last seen alive	Second fish found dead	Third fish last seen alive	Third fish found dead
	0%	2	27:45	8:30	2:20[1]	11:10	2:20	11:10	-	-
	0%	2	-	36:15	1:51[2]	2:20	1:51	2:20	-	-
Minnows	10%	2	27:45	8:30	2:20[3]	11:10	2:20[4]	11:10		
	10%	2	-	36:15	0:02	0:05	0:05	0:10	-	-
and	25%	2	27:45	8:30	1:45[5]	1:51	2:20	11:10	-	-
	25%	2	-	36:15	0:02	0:05	0:02	0:05	-	-
Shiners	33 1/3%	2	27:45	8:30	1:51[6]	2:20	2:20	-	-	-
(first series)	33 1/3%	2	-	36:15	0:02	0:05	0:10[7]	0:22	-	-
Minnows	10%	3	-	38:16	0:12[8]	0:20	0:39	9:29	9:29	-
and	25%	2	-	38:39	0:02[9]	0:08	0:08	0:16	0:08	0:16
Shiners	33 1/3%	2	-	38:39	0:08[10]	0:16	0:08	0:16	0:08	0:16
Second series										
Guppies	0%	1	27:45	10:10	9:50	-	-	-	-	-
(Lebistes	0%	1	-	37:55	9:50	-	-	-	-	-
reticulatus	10%	1	27:45	10:10	9:50	-	-	-	-	-
	10%	1	-	37:55	9:50	-	-	-	-	-
	25%	1	27:45	10:10	9:50	-	-	-	-	-
	25%	1	-	37:55	9:50	-	-	-	-	-
	33 1/3%	1	27:45	10:10	9:50	-	-	-	-	-
	33 1/3%	1	-	37:55	9:50	-	-	-	-	-

[1] Normal at 0:10; lapping at 0:55 and 1:20; one on back at surface for some time at 1:45; both dying at 2:20.

[2] Lapping at surface at 0:05, 0:55 and 1:20, indicating absence of dissolved oxygen; one on back at surface for some time at 1:45; weakening at 1:51.

[3] Nearly normal at 0:05, 0:55 and 1:20; lapping at 1:45 and 2:20.

[4] This one nearly dead at 0:05.

[5] At surface and one weakening at 0:05; losing equilibrium for some time at 0:55; one belly up at 1:20, and nearly dead at 1:45; remaining one weakening at 2:20.

[6] Somewhat wild at 0:05 at 0:55; one losing equilibrium at 1:20 (lost at 1:45); the one minnow which lived through was the only Campostoma used in the experiment.

[7] Spasmodic at 0:05.

[8] Wild and one losing equilbrium at 0:03; one on back at surface and other losing equilibrium at 0:12.

[9] Lost equilibrium very soon; other fish dying at 0:08.

[10] All dying at 0:08.

deaths were not due solely to these circumstances is clear from the fact that the fishes died much faster in the solutions which had not been previously aerated than in those which had been aerated (see Table III). Clearly weakened fishes may succumb to dilutions of this sewage effluent, even if healthy fish may not. The evidence indicates that one day's thorough aeration of the effluent would probably largely destroy such fish-killing as it may have.

Experiment 5

This experiment was almost the same as Experiment 4, except that the solutions were made up anew, using a sample of sewage effluent which had been kept at aoubt 23° C. in a sealed fruit jar for about 38 hours. Dilutions of 0%, 1%, 2% and 5% were made up, in duplicate, into one liter solutions in two-quart fruit jars. The temperature was brought to that of the room (21.5°C). The duplicate solutions were made up about 11:35 P.M. February 25, and the fish added to one set at 11:45 P.M. same day, and to the other set at 10:35 A.M. February 26. Two minnows were used in each jar. No aeration was used. Results are given in Table IV.

Table IV

Summary of Results of Experiment 5. Figures refer to hours and minutes.

Strength of solution in terms of sewage	Time exp. started after making up solution	First fish belly up and weak	First fish last seen alive	First fish dead	Second fish last seen alive	Second fish dead
0%	0:10	-	14:35	16:30	14:35	16:30
0%	11:00	4:30	4:30	4:55	4:30	4:55
1%	0:10	-	12:15	14:35	14:35	16:30
1%	11:00	-	2:35	4:30	2:35	4:30
2%	0:10	12:00	12:00	12:15	12:15	14:35
2%	11:00	-	2:35	4:30	2:35	4:30
5%	0:10	12:00	12:15	14:35	12:15	14:35
5%	11:00	-	1:10	2:35	2:35	4:30

Conclusion from Experiment 5.— This experiment shows again that even weak solutions of the Dearborn sewage effluent may kill somewhat weakened minnows and shiners, after the solutions have stood for some hours without aeration. But the fish died almost as fast in the controls containing no sewage.

GENERAL CONCLUSIONS

The sewage effluent from the new sewage disposal plant at Dearborn contains ~~disposal~~ nothing that is at all strongly toxic to fish. It contains obviously a rather high organic content, even a considerable amount of material in suspension. Under ordinary conditions, this sewage effluent if considerably diluted can hardly be regarded as particularly harmful to fish life, assuming of course that the sample was a fair and representative one. Under certain conditions of limited dilution and of considerable stagnation, especially in hot weather, it may be harmful to fish. Just how the effluent compares with that of well diluted but untreated sewage and with that of other systems of sewage treatment we are not prepared to state with definiteness.

The organic particles present in the effluent may be somewhat noxious. The pollution of the Mississippi River is becoming acute because the clay silt on deposition in quiet stretches carries down with it the sewage particles to produce an over-rich bottom mud which adversely affects the fishes, mussels and food organisms. To some degree, the Dearborn sewage may act likewise. A really clear sewage effluent is certainly desirable.

We did not consider the bacterial quality of this effluent, nor did we deal with it chemically. We did test its pH, as we were told this sewage might run high in alkalinity. About 13 hours after the sample was received it tested only 8.0 (2 tests). The 100% non-aerated sample containing fishes, at 12° C, had the pH reduced to 7.6.

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