SOME POTENTIAL USES OF INDUSTRIAL WASTE WATER IN FISH CULTURE

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Abstract. The use of an industrial waste water treatment facility is examined for cultivation of rainbow trout, striped bass, and the production of aquatic crustaceans to be utilized as food for Maine lobster and fish rations. Six month survival and growth of caged rainbow trout, without supplemental feeding, was similar to values obtained at a local trout farm. The five day old striped bass larvae experienced 100 percent mortality while a three month test of juvenile Maine lobster on rations of water fleas resulted in 85 percent survival. The trout contained detectable amounts of mercury and chlorinated hydrocarbon residue with lower levels of these substances being found in the water of the cultivation pond.

INTRODUCTION

The increasing demands on the limited fresh water resources of California have focused attention on methods to promote multiple use of existing water consumption systems. In a search for water suitable for aquaculture Garrapata Fisheries has joined with the City of Salinas, to test the feasibility of utilizing the City Industrial Wastewater Treatment Facility for the cultivation of fish and other aquatic organisms. The objective of this report is to present the results of a seven month examination of the facility for aquaculture potential.

I thank the following people and agencies for their support of the project: Northern Salinas Valley Mosquito Abatement District, the City of Salinas and the staff of the Industrial Wastewater Treatment Facility, Ronald L. Mull, DVM, Ph.D., Toxicologist, Cooperative Extension, University of California. I also thank Thomas Thompson, Ph.D. Area Marine Advisor, Cooperative Extension, University of California.

METHODS

Facility Description

The Industrial Wastewater Treatment Facility of the City of Salinas, California, is located 2.5 miles west of Salinas adjacent to the Salinas River.

Fig. 1. Diagram of the City of Salinas industrial waste water treatment facility.

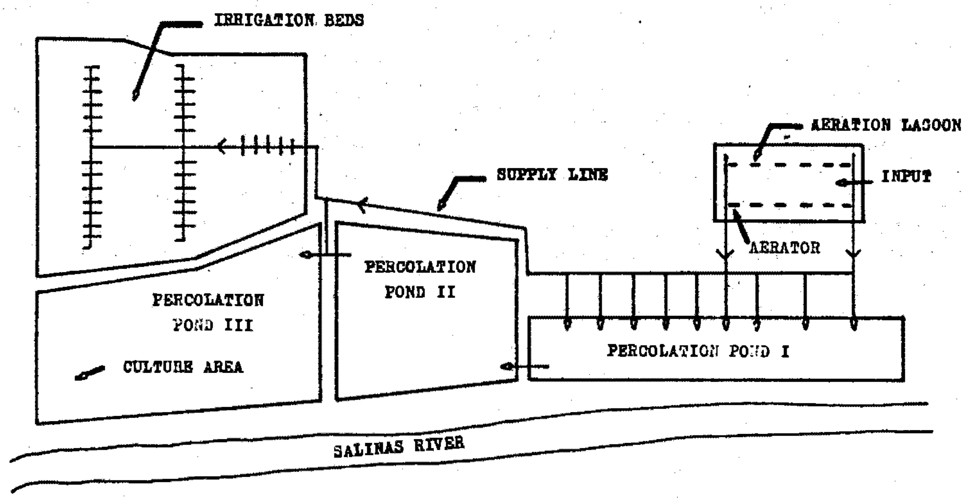
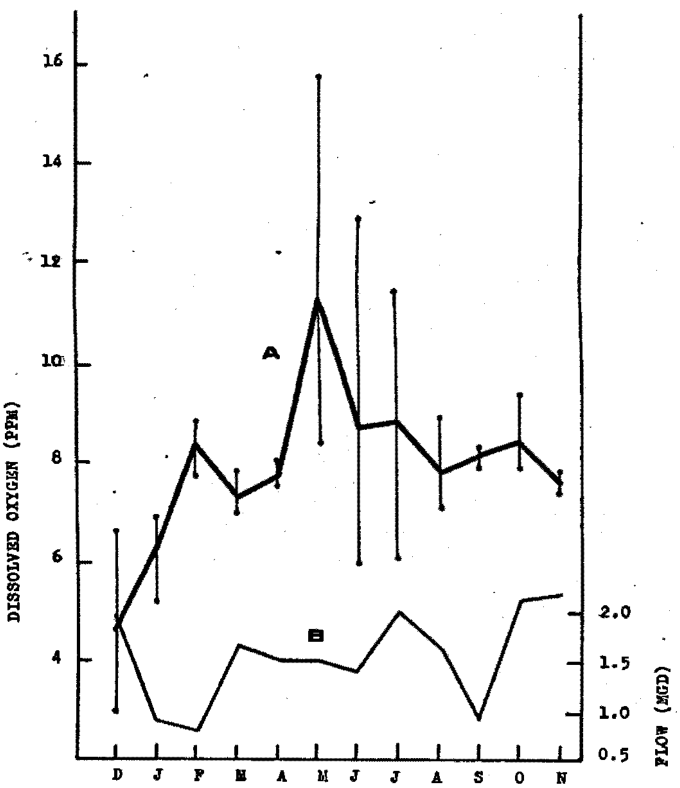


Fig. 2. Graph A - monthly average and range of dissolved oxygen in percolation Pond 3.
Graph B - daily average input to oxidation pond.



The facility was constructed in 1972 for the treatment of industrial process water. In the first treatment step the wastewater enters a 13 acre aeration lagoon (Figure 1) where twelve 50 horsepower aerators agitate the water with the capacity to treat 22,500 lbs. BOD_5 per day at a removal efficiency of 90 percent. At the design average flow of 4 MGD (million gallon per day), the wastewater is detained for 10 days in the 40 million gallon lagoon. The water gravity flows from the aeration lagoon to a series of three percolation ponds of 42, 29 and 39 acres with a combined capacity of 230 million gallons at an average depth of 2.2 meters. The percolation ponds were designed to dispose of 2.7 MGD by percolation into the porous ground. The ponds are connected in series allowing water to flow through pond 1 to pond 2 and terminally to pond 3. Water quality is usually highest in pond 3 due to the biological activity on the water in the preceding ponds. When the average daily input to the facility exceeds the infiltration capacity of the percolation ponds the wastewater can be carried directly from the aeration lagoon to 61 irrigation beds of a total surface area of 64 acres. Effluent can also be directed into the irrigation beds from percolation ponds 1 and 2.

Water Quality

Staff of the Salinas Sanitary District took daily water samples to analyze for dissolved oxygen by a modified Winkler technique. A flow meter at the facility measured the daily input to the facility. Ammonia, pH, and temperature were recorded monthly by the staff of the Regional Mosquito Abatement District. Analysis for ammonia was performed by the nesslerization process with a Bausch and Lomb model 20 spectrophotometer, pH determined with a Corning model 20 pH meter, and temperature recorded from a mercury thermometer. The amount of unionized ammonia present was calculated by the method described by Emerson (1975). All monitoring of water quality occurred during daylight hours. Chemical analysis of the trout was provided by the Department of Environmental Toxicology at the University of California, Davis. The water analysis was performed by a commercial chemical analytic laboratory.

Fish Culture

Water fleas (Daphnia sp.) were collected from pond 3 by a fine meshed dip net and transported to the lobster hatchery in Monterey. The Daphnia constituted 100 percent of the diet of 3000 juvenile Maine lobsters (Homarus americanus) for 90 days fed at a rate of 1-2 percent body weight per day.

Two floating, rigid cages 0.7m x 0.5m x 3m were covered with 450 micron nylon netting and placed in the west end of pond 3. On 20 April 1976 approximately 200,000 4-5 day old striped bass larvae (Roccus saxatilis) were received in apparent good health from the South Carolina Department of Fish and Game. Approximately one half of the larvae were placed in each cage after the water in the fish transport bags was similar to the ambient water temperature of the pond.

Two floating, rigid cases 1m x 1m x 3m were constructed with 2mm nylon netting on 5 sides and no top covering. In addition one cage 0.3m x 0.3m x 0.4m was utilized with 3mm wire screen on all sides. All cages were secured approximately 75m from the west end of pond 3. On 8 April 1976 three size classes of rainbow trout (Salmo gairdneri) were transported from the Garrapata Trout Farm, Carmel, California to the Salinas facility. Ten 20-25 cm fish were placed in large cage 1, fifteen 7.5-12.5 cm fish were placed in cage 2, and twenty 2.5 cm fish placed in the small cage.

Sporadic supplemental feeding was stopped after 30 days when the fish ceased accepting commercially prepared trout pellets. During the first 60 days the fish in the two large cages were netted every three weeks for random qualitative observation of their general condition of health. The fish

Fig. 3. Monthly temperature and pH for percolation Pond 2.

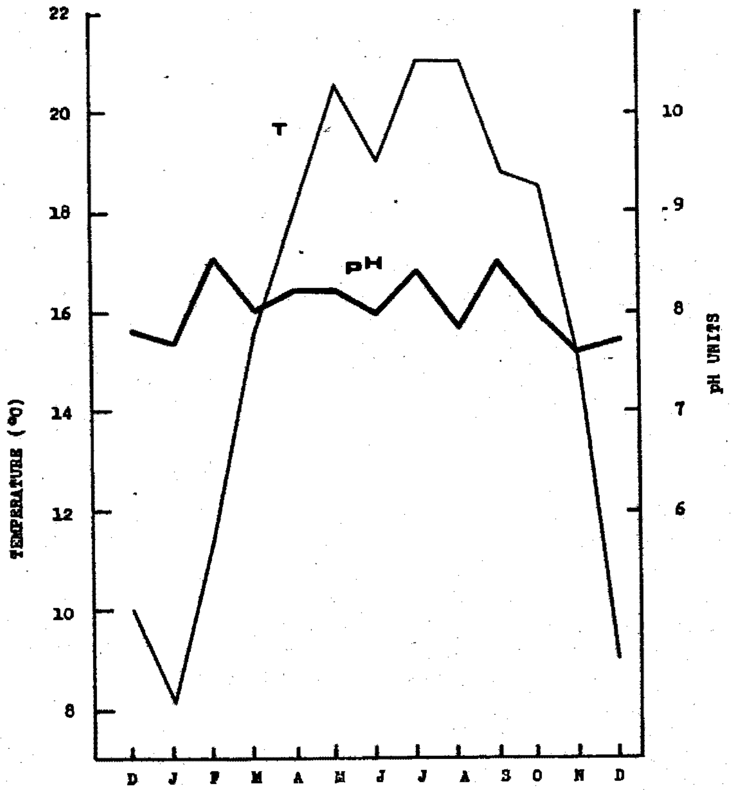
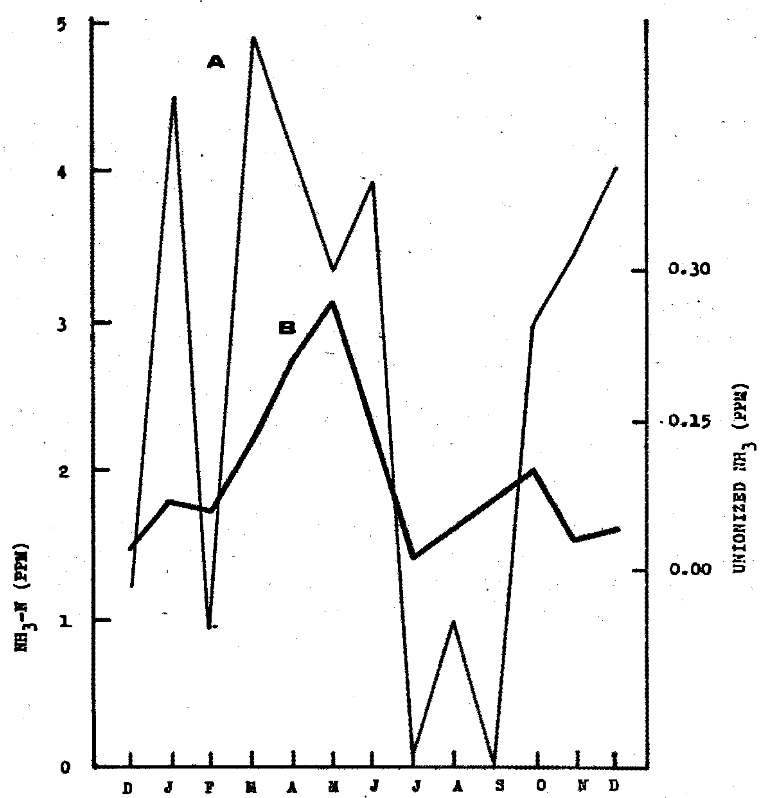


Fig. 4. Graph A - monthly measured ammonia level in percolation Pond 2. Graph B - calculated monthly unionized ammonia level in percolation Pond 2.



in the smaller cage were observed in the same gross manner but without individual handling due to the ease of examination of the entire population within the small cage. For the remainder of the study the fish in the smaller cage were observed sporadically. After five and six months fish were sacrificed for chemical analysis and observation of general health.

RESULTS

Water Quality

The dissolved oxygen content of pond 3 water (Figure 2A) where the fish were cultivated ranged from a minimum of 3 ppm (parts per million) in December to a maximum of 16 ppm in June. The monthly average ranged between 5 ppm and 11 ppm. The monthly recorded temperature for percolation pond 3 (Figure 3) varied from 8°C to 21°C. The minimum temperature occurred during winter and the maximum occurred during summer. The pH of pond 2 varied between 7.6 and 8.5 pH units (Figure 3). Figure 4 illustrated the measured ammonia levels in pond 2.

Fish Culture

The lobsters fed *Daphnia* obtained from pond 3 experienced an 85 percent survival rate with successful molts in apparent but nonquantified growth.

The larval striped bass experienced 100 percent mortality within 24 hours after introduction to the water of pond 3. It was noted that the fine mesh opening of the 450 micron netting easily became occluded with the unicellular and filamentous algae which was abundant in the pond.

The 2.5 cm rainbow trout experienced 100 percent survival and the 8 fish remaining after sacrifices averaged 15.2 cm with a range of 12 cm to 18 cm. The average growth in length was 12.7 cm. Five of the 20-25 cm class fish and five of the 7.5-12.5 cm fish were sacrificed for chemical analysis. A total of 0.5 ppm of the chlorinated hydrocarbon DDT and its metabolites and 0.7 ppm of mercury were detected in the analysis of the whole fish. Two of the largest size class were also sacrificed for observation of intestinal contents and gill filaments. The stomach contents were composed of mainly gammarid amphipods with a small amount of *Daphnia*. The gill filaments appeared normal without the gill tissue hyperplasia that Spotte (1970) reported to occur when fish were exposed to high levels of ammonia.

Before a growth measurement of the two large size class fish could be accomplished 100 percent mortality and disappearance of the remaining fish occurred. A great blue heron was occasionally observed perched on the edge of the uncovered cages and mortality may be attributed to predation.

DISCUSSION

The survival and growth rates of the small size class rainbow trout compares with the production figures for growth of trout on rations of 2.5-3.0% body weight per day at the Garrapata Trout Farm. This result suggests the possibility of utilizing the Industrial Wastewater Treatment Facility as a trout rearing facility. The 0.7 ppm mercury level detected in the trout is above the 0.5 ppm mercury guideline set by the F.D.A. (Zook, *et al*., 1976).

A National Marine Fisheries Service survey of selected seafoods for mercury and other toxic chemicals found some seafoods to contain on the average more than 0.6 ppm but less than 1.0 ppm mercury (Zook *et al*. 1976). The 0.5 ppm DDT found in the trout is below the permissible 1.25 ppm DDT content of dairy products.

Table 1. Industries discharging into Industrial Waste Water System.

Name of Industry	Nature of Operation
Alameda Frozen Foods	Process, package and freeze carrots.
Aliotti Fish Co.	Process fresh fish and squid.
Hoerner Waldorf Corp.	Corrugated paper box manufacturing.
Salinas Valley Vegetable Exchange	Process and packing of celery.
Mann Packing Co.	Vegetable packing.
The Nestle Co.	Chocolate product manufacturing.
Spiegl Foods, Inc.	Packing and freezing of vegetables.
U.S. Freezer	Packing of fresh fish and squid.
John Inglis Frozen Foods	Processing, packing, and freezing of vegetables.

Table 2. Chemical Analysis of water from Pond 3, 4/28/76.

Test		mg/l (Or as stated)	Public Health Drinking Water Limits
pH value	(units):	8.3	10.6
Conductivity	(micromhos/cm):	1260	-
Carbonate Alk	(as $CaCO_3$):	0	
Bicarbonate Alk.	(as $CaCO_3$):	380	120
Total Alkalinity	(as $CaCO_3$):	380	-
Total hardness	(as $CaCO_3$):	368	-
Total Salts	(electrometric):	882	500
Nitrate-Nitrite	(N):	0.8	10
Chloride	(Cl):	212	250
Sulfate	(SO_4):	105	250
Fluoride	(F):	0.2*	250
Calcium	(Ca):	68	1.5
Magnesium	(Mg):	48	-
Potassium	(K):	66	-
Sodium	(Na)	170	-
Iron Total	(Fe):	0.62	0.3
Arsenic	(As):	0.01*	0.1
Cadmium	(Cd):	0.002*	0.01
Chromium	(Cr):	0.0005*	0.05
Copper	(Cu):	0.01*	1.0
Cyanide	(Cn):	0.01*	0.2
Lead	(Pb):	0.01*	0.05
Mercury	(Hg):	0.0001*	0.005
Zinc	(Zn):	0.030	5.0

Total identifiable hydrocarbons 0.1

*Less than this level.

A current project to introduce to the facility 5000 rainbow trout and 5000 silver salmon (Oncorhynchus kisutch) will analyze the fish culture potential at a more significant population level. The feasibility of utilizing endemic aquatic crustaceans for lobster rations appears high with improvement of the harvesting technique required.

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