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Microbial and Chemical Properties of Log Ponds Along the Oregon Coast

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Abstract

The microbial and chemical properties of log ponds along the Oregon coast were investigated. The log ponds were highly eutrophic, containing high concentrations of ammonium and nitrate nitrogen, phosphate, and organic compounds. Because of large microbial populations, the biochemical oxygen demand was high and dissolved oxygen was low. Bacterial species in log ponds were relatively similar to those found in streams with rich nutrient content. Most of the fungi in log ponds were lymabiont and lymaphilous. Some fungal species reportedly associated with fish disease were present in log ponds and in ponds without log storage as well.

Keywords: Biochemical oxygen demand, bacteria, fungi, residue.

Introduction

Log ponds are used by lumber companies to clean and move logs at mill sites. Water in a log pond differs from other bodies of water: it is stagnant because no outflow occurs, and it accumulates organic matter from a continuous supply of log debris. Pease (1974) reports high concentrations of log leachates and high biological oxygen demand in marine log-raft storage sites in southeastern Alaska.

Log-storage ponds are a common feature of the western forest region. When they are adjacent to a stream, they may affect water quality. This study was done to determine the seasonal changes of chemical and microbial properties in log ponds along the Oregon coast.

Materials and Methods

The log ponds we studied are in the Willamette Valley of western Oregon. Four ponds with diverse environments were selected.

Pond 1 is 10.4 km west of Corvallis on the east slope of the Coast Range. It is about 40 m wide, 50 m long, and 5 m deep. This pond has been used infrequently and was left unused for 5 years in the late 1960's. In April 1970, the water was drained and the pond was deepened; logs have since been stored there. It is owned by the Mika Lumber Company.

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Pond 2 is 16 km west of Corvallis. It is about 30 m wide and 80 m long with a maximum depth of 3.5 m. This pond has not been used for a long time. The water was used primarily for a saw mill, which belonged to the Three G Lumber Company.

Pond 3 is the largest of the four ponds at about 70 m wide and 200 m long with a maximum depth of 4 m. It is 32.2 km east of Corvallis near Lebanon. This pond has been in continuous use and was formerly owned by the Champion International Corporation.

Pond 4 is 3.2 km east of Corvallis. It is about 60 m wide and 80 m long with a maximum depth of about 3 m. It is a recreation pond created during highway construction in 1960. This pond was used as the control.

Water samples were taken during January, April, July, and October 1970 to represent seasons of the year. Separate 500-mL bottles were used for analyses of nutrients, microorganisms, and oxygen. Four replicate water samples were taken from each pond between 10 and 11 a.m. All samples from a given pond were taken the same day. The water samples were refrigerated. All chemical and microbial analyses were made within 5 days of sampling, and all analyses were done in duplicate. Each duplicate was averaged to represent each of the four replicates.

Chemical Analysis

Water temperature was measured 30 cm below the water surface with a clinical thermometer. A 100-mL portion was allowed to warm to 25 °C before pH was determined with a Beckman meter.

Organic matter was determined as the amount of nonfilterable and filterable residue. Two 100-mL aliquots were passed through a weighed 0.22-µm Milipore[1] filter membrane; the filter membrane with its contents was then ovendried at 110 °C for 24 hours, after which it was weighed to determine nonfilterable residue. Twenty-mL samples of each of the filtrates were evaporated to constant weight in a weighed, disposable aluminum dish at 110 °C. The filtrate residue included all materials passing through the Milipore filter membrane that were nonvolatile during the drying.

Ammonium nitrogen was estimated with the direct Nesslerization method by alkalizing with NaOH and precipitating interfering elements with zinc sulfate (Greenberg and others 1980). After filtration, EDTA and Nessler reagent were added, and transmittance was measured at 425 nm. Nitrate nitrogen was estimated using the ultraviolet spectrophotometer method (Greenberg and others 1980). The samples were filtered and acidified. A measurement of ultraviolet absorption at 220 nm and a second measurement at 275 nm to correct for interference of dissolved organic matter were used for comparison with standard curves.

Phosphate analyses were made by the ammonium molybdate-stannous chloride method at 690 nm (Greenberg and others 1980).

Tannin or tanninlike substances are a bark constituent of logs. These substances are aromatic hydroxyl groups that react with tungstophosphoric and molybdophosphoric acids to form an intense, colored complex. The existence of tannin and tanninlike

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[1] Use of a trade name does not imply endorsement or approval of any product by the USDA Forest Service to the exclusion of others that may be suitable.

substances were estimated by the spectrophotometric method (Greenberg and others 1980) at a 700-mm wavelength (Lackey 1939) using standards for tannic acid.

Total carbon analyses were made on ovendried water samples of known volume by combustion at 1100 °C. This method was modified from the methods of Tabatari and Bremner (1983).

Determinations of dissolved oxygen (DO) and biochemical oxygen demand (BOD) were done by the azide modification of the iodometric method (Greenberg and others 1980). Water samples were collected in ground-glass, stoppered, narrow-mouthed bottles of 25-mL or 300-mL capacity. Dissolved oxygen of water samples was determined within 24 hours. Biochemical oxygen demand was measured at 5 days. Samples taken from pond 4, and later from pond 2, were diluted with oxygen-saturated distilled water of known concentration in both the DO and BOD determinations.

Microbial Investigation

Bacterial populations were determined with plate counts using serial dilutions with sterile water. Twenty mL of Difco nutrient agar was cooled to 40 °C and poured on each plate. Incubation was at 25 °C and counts were made after 48 hours. Bacteria were identified on 10 different colonies per plate using morphological and biochemical tests described in Bergey's manual (1974).

The isolation of Hyphomycetes was determined in 1 mL of water spread on neopeptone-dextrose-rose bengal-aureomycin agar (Coker and Mathews 1923). Fungal colonies occurring on plates were transferred to potato-dextrose agar slants and plates for microscopic identification.

Fungi belonging to Oomycetes and Chytridiomycetes were isolated in water samples placed in glass dishes containing hemp seeds, bark beetles, fingernails, grass, leaves, and pollen grains previously sterilized as baits. Covered culture dishes were incubated at 25 °C for 2 weeks. Microscopic identifications were made of fungi that fruited.

Results and Discussion

The log ponds along the Oregon coast are highly eutrophic, being characteristically rich in inorganic nutrients, such as ammonium, nitrate nitrogen, phosphate, and tanninlike substances (table 1). This, in turn, leads to intense heterotrophic activity (as measured by bacterial abundance), increased BOD, and decreased DO (tables 2 and 3, fig. 1).

Nitrogen (in the form of ammonium and nitrate) is often a limiting nutrient for primary productivity. The availability of these forms are greatly dependent on the decomposition and recycling of organic nitrogen through microbial (mainly bacterial) mineralization (Riemann 1983). Phosphate can also increase the rate of organic matter decomposition and thus the inorganic nitrogen content in water (Elwood and others 1981). The nitrogen content in the log ponds was less in October, probably because of the high bacterial population and microbial immobilization and nitrate reductase formation (table 3).

The concentration of organic material may be low in many natural waters, such as springs and open ocean. Levels of dissolved and particulate organics in the sea usually range between 0.3 and 2.0 mg/L (Rheinheimer 1980). The log ponds of the Oregon coast are more organically rich environments (table 2).

Table 1—Chemical composition of log ponds along the Oregon Coast[1]

Month	pH	Carbon C	Ammonium nitrogen NH_4	Nitrate nitrogen NO_3	Phosphate PO_4	Tanninlike substance
		Parts per million				
January	5.6	0.95 aB	587 aB	106.7 C	0.24 b	2.2 b
	(5.5)	(.55) aA	(60) aA	(180)	(.19)	(1.4)
April	7.0	.68 b	6.2 c	900 aB	.27 b	3.5 b
	(7.9)	(.50) a	(0)	(240) A	(.12)	(1.0)
July	6.9	.85 aB	6.7 C	420 bB	1.70 a	9.3 aB
	(7.7)	(.32) bA	(0)	(40) A	(0)	(.5) A
October	6.6	.57 bB	273.3 bB	40 c	.98 aB	8.2 aB
	(7.1)	(.27) bA	(40) bA	(20) D	(.09) A	(1.5) A

[1] Data are means of 3 log ponds (N = 12). Means within parentheses represent the pond without log storage. The means not sharing a common lower case letter within a column and among log ponds differ significantly among seasons by the Tukey test at P≤0.05. The means not sharing a common capital letter between the log ponds and the pond without logs differ significantly by Tukey test at P≤0.05.

Table 2—Organic compounds, oxygen, and temperature in log ponds[1]

		Organics		Oxygen	
Month	Temperature	Dissolved form	Particulate form	Dissolved oxygen	Biochemical oxygen demand
	°C	*Parts per million*			
January	7.6	130 b	56 aB	6.7 a	3.9 bB
		(120)	(14) A	(9.6)	(2.0) a
April	15	98 b	68 aB	5.7 aB	3.4 b
		(90)	(18) A	(9.6) A	(3.6)
July	2	1166 aB	49 aB	2.7 bB	4.5 bB
		(95) A	(11) A	(9.4) A	(3.0) A
October	10.8	114 b3	31 bB	5.2 aB	5.8 aB
		(110)	(10) A	(10.8) A	(4.3) A

[1] Data are means of 3 log ponds (N = 12). Means within parentheses represent the pond without log storage. The means not sharing a common lower case letter within a column and among log ponds differ significantly among seasons by the Tukey test at P≤0.05. The means not sharing a common capital letter between the log ponds and the pond without logs differ significantly by Tukey test at P≤0.05.

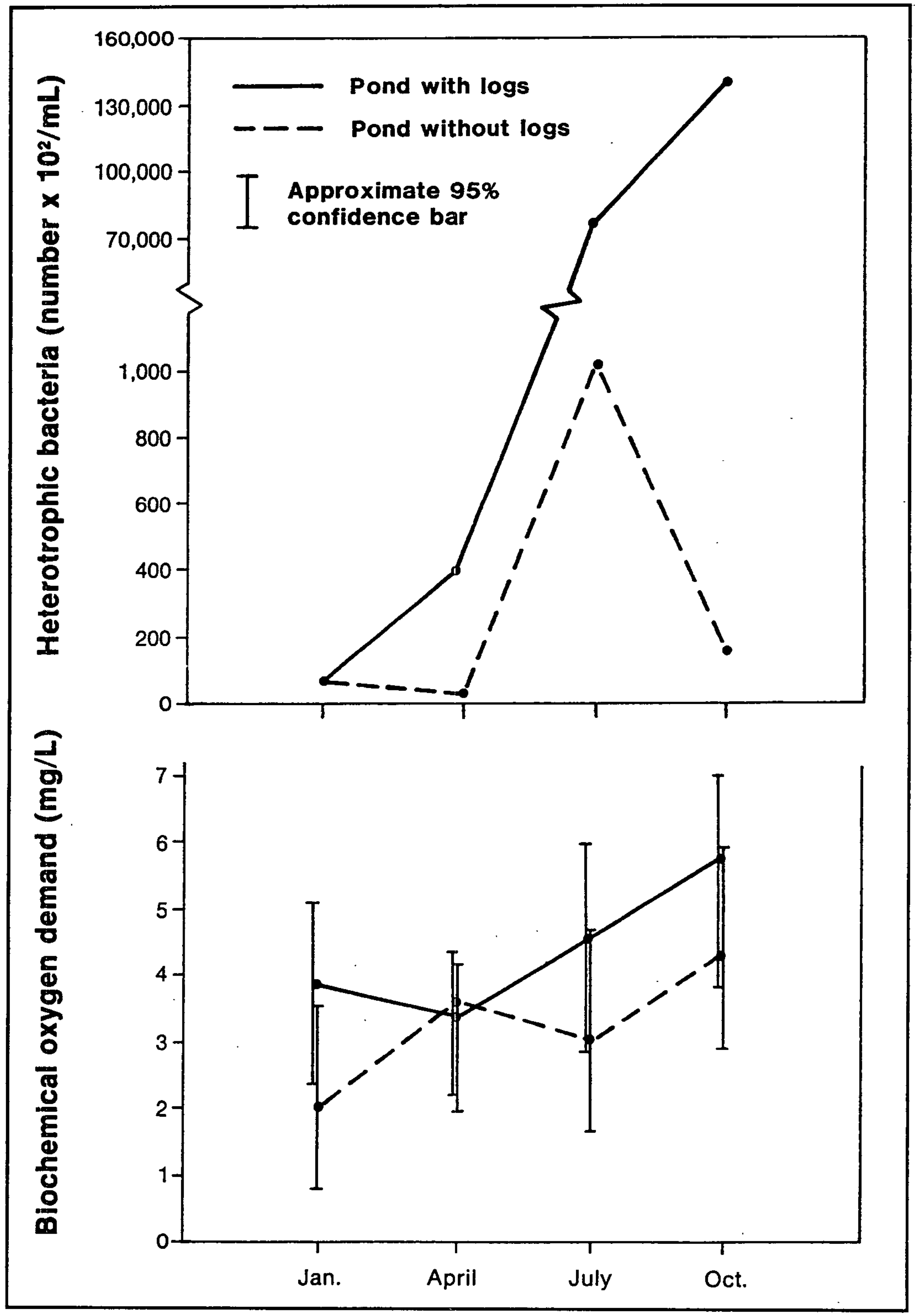

Figure 1—Relation between biochemical oxygen demand, number of heterotrophic bacteria, and month of the year.

Bacterial species generally occur in the log ponds, particularly bacteria from the families Pseudomonaceae, Bacillaceae, Enterobacteriaceae, Micrococcaceae, and Streptomycetaceae (table 4). A similar phenomenon is reported for a stream with increasing nutrient content (Fletcher 1979).

Table 3—Abundance of bacteria in log-pond water[1]

	Bacteria per mL water (number x 10^2)	
Month	Log pond	Control
January	53 b	50 b
April	412 bA	35 bB
July	75,100 aA	1320 aB
October	155,800 aA	162 bB

[1] Data are means of 3 log ponds (N = 12). Means within parentheses represent the pond without log storage. The means not sharing a common lower case letter within a column and among log ponds differ significantly among seasons by the Tukey test at P≤0.05. The means not sharing a common capital letter between the log ponds and the pond without logs differ significantly by Tukey test a P≤0.05.

Table 4—Bacteria identified in log-pond water, by month [1] [2]

Bacteria	January	April	July	October
Bacillaceae:				
Bacillus cereus var. *mycoides* (Flügger) Smith	1	C	2,C	3,C
B. megaterium de Bary	1	2,C	2,C	
Enterobacteriaceae:				
Euterobacter aerogenes Hormaeche and Edwards	1,2,3,C			1,2,3,C
Proteus morganii (Winslow, Kligler, and Rothberg) Yale	3		3	1,3
P. vulgaris Hauser	3			2,3
Micrococcaceae:				
Microccocus luteus (Schroeter) Cohn	1,2,C	C		2,C
Pseudomonaceae:				
Pseudomonas aeruginosa (Schroeter) Migula	1,2,3		3	1,2,3
P. syringae van Hall	1,2,3,C		C	1,2,3,C
Streptomycetaceae:				
Streptomyces albus (Rossi Doria) Waksman and Henrici	3		1,3	1,3
Uncertain affiliation:				
Flavobacterium sp.	1,2,C	2,C	2,C	1,2,3,C
F. breve (Lustig) Bergey and others	1,2,C	2,C	2,C	2,C

[1] 1, 2, and 3 are ponds with logs and corresponds to ponds 1, 2, and 3 in the text.

[2] C is the pond without logs and corresponds to pond 4 in the text.

Fungi, including yeasts and molds, were present in the log ponds, but higher Basidiomycetes were not found (table 5). Most of the fungi were lymabiont and lymaphilous, as found in sewage and polluted stream water (Cooke 1976). *Saprolegnia* is the most important fungal parasite of fish. Scott (1964) found that *S. ferax* and *S. delica* can kill *Xiphophorus* sp. (platys). *Aphanomyces laevis* can grow on wounded platys (Vishniac and Nigrelli 1957).

Table 5—Fungi isolated and identified from log-pond water, by month[1] [2]

Fungi	January	April	July	October
Oomycetes:				
Achyla sp.	1	2	2	2
A. americana Humphrey	1,2	2,C	2	2,C
A. dabryana Humphrey	1,C	2,C		3,C
A. klebsiana Pieters	1,2	2	2,C	2,C
Aphaomyces sp.	1,2,3	3,C	2,C	2,C
A. laevis de Bary	1,2,C	2,C	2,C	2,C
A. scaber de Bary	3	3		3
A. stellatus de Bary	1	C		
Dityuchus sp.	C	C	C	
Saprolegnia sp.	1,2,3,C	2,C	2,C	2,3,C
S. delica Coker	3,C	C	2,C	2,C
S. ferax (Gruith.) Thur.	2,C	C	2,C	2,3,C
Ascomycetes:				
Neurospora sp.			2	1
Zygomycetes:				
Rhizopus nigricans Ehrenberg	3	2	2,3	
Fungi imperfecti:				
Aspergillus flavus Link and Link	1		1	1
A. nidulans Eidam	C	C	C	
A. niger Van Tieghem	2,3	2,3	1,2,3	
Botrytis cinerea Persoon ex Fries			1	
Candida krusei (Castellani) Berkhoot	3	3	3	3
Cladosporium herbarum (Persoon) Link	1,2,3	2		2
Epicoccum nigrum Link	1,3			1,3
Fusarium oxysporum Schl.	C		C	C
Geotrichum candidum Link ex Persoon	3,C	3,C	1,3	1,3
Penicillium chryspogenum Thom				1
P. martensii Biourge	1,2,3,C	3		1,C
Rhodotorula sp.		3	3	
Trichoderma viride Lk. ex Fr.	2			

[1] 1, 2, and 3 are ponds with logs and correspond to ponds 1, 2, and 3 in the text.

[2] C is the pond without logs and corresponds to pond 4 in the text.

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