Analyses of Bottom Material From The Willamette River, Portland Harbor, Oregon

U.S. GEOLOGICAL SURVEY
Open-File Report 77-740

Prepared in cooperation with the
U.S. Army Corps of Engineers

ANALYSES OF BOTTOM MATERIAL FROM THE WILLAMETTE RIVER, PORTLAND HARBOR, OREGON

By Stuart W. McKenzie

U.S. GEOLOGICAL SURVEY
Open-File Report 77-740

Prepared in cooperation with the
U.S. ARMY CORPS OF ENGINEERS

1977

UNITED STATES DEPARTMENT OF THE INTERIOR
CECIL D. ANDRUS, Secretary
GEOLOGICAL SURVEY
V. E. McKelvey, Director

For additional information write to:
U.S. Geological Survey
P. O. Box 3202
Portland, Oregon 97208

CONTENTS

TABLES

CONVERSION FACTORS

The following factors may be used to convert the English units published herein to the International System of Units (SI). In the text, the metric equivalents are shown only to the number of significant figures consistent with the values for the English units.

Multiply	By	To obtain
Inches (in)	25.4	Millimeters (mm)
Feet (ft)	.3048	Meters (m)
Miles (mi)	1.609	Kilometers (km)
Degrees Fahrenheit (°F)	5/9 after subtracting 32	Degrees Celsius (°C)

ANALYSES OF BOTTOM MATERIAL FROM THE WILLAMETTE RIVER, PORTLAND HARBOR, OREGON

--

By Stuart W. McKenzie

--

ABSTRACT

The bottom material of the Willamette River, Portland Harbor, was sampled in duplicate on February 1, 1977. Results are reported on the following analyses of the material: immediate and long-term oxygen demand; particle size; percent moisture; residue, loss on ignition; and chemical.

INTRODUCTION

The U.S. Geological Survey (USGS), in cooperation with the U.S. Army Corps of Engineers, Portland District (Corps), collected and analyzed duplicate samples of bottom material from Portland Harbor. The analyses were selected jointly by the Corps and USGS and include chemical, oxygen-demand, and particle-size analyses of the bottom material.

This study resulted from decisions made at a meeting attended jointly by the Corps, National Marine Fisheries Service (NMFS), and USGS on January 13, 1977. At this meeting the Corps outlined a pilot dredging program. This program included: (1) Dredging bottom material from the Willamette River in the Portland Harbor, (2) placing the dredged material in a hopper barge, (3) transporting the material to the Columbia River, and (4) dumping the material into the Columbia River.

The NMFS indicated that, at present, the Columbia River downstream from Bonneville Dam receives very little organic material (oral commun., George Snyder, January 13, 1977). The bottom material to be dredged is 5 to 8 percent organic (unpub. data, USGS), and NMFS indicated that this material could stimulate the Columbia River aquatic system, with the dumping sites serving as feeder sites for aquatic organisms. The USGS study will provide some information on what may happen should the pilot dredging program proceed.

RESULTS

Sample Collection

Two samples (A and B) of bottom material were collected from the Portland Harbor at river mile (RM) 9.2 on the morning of February 1, 1977. The samples were taken at a point 30 percent of the water-surface width from the left bank. The sampling device was a tall Ekman dredge equipped with lead weights. The dredged samples had dimensions 8 in (200 mm) in depth and 6 in by 6 in (152 mm by 152 mm) in area. Each sample was subdivided into four aliquots for analysis. Each aliquot contained material in the entire 8 in (200 mm) of depth. They were refrigerated in specially prepared glass bottles. Disposition of the material is shown in table 1. Willamette River water was also taken near RM 9.2 at 3-ft (1-m) depth as dilution water for the oxygen-demand tests.

Table 1.--Disposition of sampled material from Portland Harbor

	Sample A	Sample B
Aliquot 1	Portland laboratory	Portland laboratory
2	Central laboratory	Central laboratory
3	NMFS (for organics)	Stored for backup
4	Stored for backup	Stored for backup

Oxygen Demand

The immediate oxygen-demand test was run on the afternoon of February 1, 1977 (day of collection). The test procedure involved (1) filling 300-ml (milliliter) biochemical-oxygen demand (BOD) bottles with Willamette River dilution water; (2) measuring the dissolved oxygen (DO) with a YSI1/ self-stirring BOD-DO temperature probe and a YSI meter; (3) placing either 2 or 5 ml of wet sediment into the BOD bottles; and (4) recording DO readings at 1-, 2-, 3-, 4-, 5-, 10-, 15-, and 30-minute intervals and thereafter at about 1-, 2-, and 7-hour intervals. The stirring mechanism mixed the sediment thoroughly with the dilution water. These sediment samples are subsamples of aliquot 1, samples A and B. Table 2 shows the oxygen consumed in 10 and 30 minutes and in 2 and 7 hours, with units of milligrams of oxygen per milliliter (mg/ml) of sediment and pounds of oxygen per cubic yard (lb/yd^3) of sediment.

1/ The use of brand names in this report is for identification purposes only and does not imply endorsement by the U.S. Geological Survey.

Table 2.--Immediate and long-term oxygen demand of bottom material

[K_1, rate of oxygen consumed]

Sample identification	A_1		A_2		A_3		A_4		B_1		B_2	
Sample volume	2 ml		5 ml		2 ml		5 ml		2 ml		5 ml	
$\frac{O_2 \text{ consumed}}{\text{Vol wet sed}}$	$\frac{mg}{ml}$	$\frac{lb}{yd^3}$	$\frac{mg}{ml}$	$\frac{lb}{yd^3}$	$\frac{mg}{ml}$	$\frac{lb}{yd^3}$	$\frac{mg}{ml}$	$\frac{lb}{yd^3}$	$\frac{mg}{ml}$	$\frac{lb}{yd^3}$	$\frac{mg}{ml}$	$\frac{lb}{yd^3}$
IMMEDIATE												
Time (hours)												
1/6	0.42	0.71	0.37	0.62	0.50	0.84	0.40	0.67	0.58	0.98	0.46	0.78
1/2	.51	.86	.49	.83	.62	1.04	.45	.76	.68	1.15	.53	.89
2	.63	1.06	.55	.93	.73	1.23	.51	.86	.85	1.43	.63	1.06
7	.75	1.30	.63	1.06	.86	1.45	.57	.96	.98	1.65	.70	1.18
LONG-TERM												
Time (days)												
5	.72	1.21	.57	.96	1.31	2.21	.53	.89	1.34	2.26	.60	1.01
10	1.18	1.99	.92	1.55	1.56	2.62	.84	1.41	1.68	2.83	1.00	1.68
20	1.80	3.03	1.39	2.34	2.49	4.20	1.42	2.39	2.86	4.82	1.65	2.78
	(K_1=0.04/day)		(K_1=0.04/day)		(K_1=0.07/day)		(K_1=0.04/day)		(K_1=0.06/day)		(K_1=0.04/day)	
IMMEDIATE PLUS LONG-TERM												
Time 20 days + 7 hr	2.55	4.33	2.02	3.40	3.35	5.65	1.99	3.35	3.84	6.47	2.35	3.96

Note: Water saturated with air at 760 mm mercury pressure and at a temperature of 20°C has a dissolved-oxygen content of 9.2 mg/L, or 0.0092 mg/ml, or 0.0155 lb/yd^3.

The long-term oxygen demand was measured by monitoring the oxygen uptake in the BOD bottles at 20°C, with the test starting at the completion of the immediate demand test (after the 7th hour). The oxygen was monitored after 0.5, 1.6, 2.5, 5.5, 7, 9, 10, 12, 16, and 20 days. Table 2 shows the oxygen consumed after 5, 10, and 20 days with the same units as immediate demand and the rate of satisfaction (K_1) per day to the base 10. The immediate plus the long-term oxygen demand is also shown in table 2. Table 2 shows that more oxygen was consumed per milliliter of sediment for the 2-ml samples than for the 5-ml samples. Possible reasons for this include: (1) The sediment-to-water ratio affects the oxygen consumed, (2) the sediment-to-bottle-surface-area ratio affects the oxygen consumed, (3) the sediment-to-dissolved-oxygen ratio affects the oxygen consumed, and (4) something in the sediment inhibits the oxygen-consuming bacteria when 5 ml is used. For greater detail on the oxygen-demand test, see Hines, McKenzie, Rickert, and Rinella (1977).

Particle Size

Table 3 shows the results of particle-size analyses of several subsamples of the bottom material. The greater than 2.0-mm to less than 0.062-mm sizes were determined by sieve analysis and the less than 0.004-mm size was determined by pipette analysis. Standard USGS procedures were used for the analyses (Guy, 1969).

Table 3.--Particle-size analyses of bottom material

Sample identification	Wet sample volume (ml)	Sieving method	Percentage of dry weight							
			> 2.0 (mm)	< 2.0 (mm)	< 1.0 (mm)	< 0.5 (mm)	< 0.25 (mm)	< 0.125 (mm)	< 0.062 (mm)	< 0.004 (mm)
A_2	10	Dry	0	100	100	99	97	86	69	15
A_3	10	Dry	0	100	100	99	97	92	75	12
A_4	10	Wet	0	100	100	99	95	83	66	12
B_1	10	Wet	0	100	100	99	96	86	68	11
B_2	10	Dry	0	100	100	100	99	91	76	15
B_3	10	Dry	0	100	100	99	97	92	75	12
Median			0	100	100	99	97	88.5	72	12

Moisture and Residue, Loss on Ignition

Table 4 includes the percent moisture; dry weight; and residue, loss on ignition of samples of bottom material. Dry weight and percent moisture were determined by drying the samples for 24 hours at 100°C plus 1 hour at 105°C. The residue, loss on ignition, analyses were run at 550°C for 30 minutes and indicate the amount of material that was burned. These analyses were done according to standard procedures (Am. Public Health Assoc. and others, 1975).

Table 4.--Percent moisture and residue, loss on ignition, analyses of bottom material

Sample identification	Wet sample volume (ml)	Moisture (percent)	Dry weight		Residue, loss on ignition		
			(g/5 ml)	(lb/yd^3)	(percentage of dry weight)	(g/kg)	(lb/yd^3)
A_1	5	53.3	3.52	1,190	7.7	77	92
A_2	5	53.4	3.14	1,060	7.6	76	81
A_3	5	53.5	3.41	1,150	7.8	78	90
B_1	5	53.5	3.65	1,230	7.7	77	95
B_2	5	53.7	3.46	1,170	7.5	75	88
B_3	5	54.3	3.43	1,160	7.6	76	88
Median		53.5	3.45	1,165	7.6	76	89

Chemical Analyses

Chemical constituents of the bottom material, shown in table 5, were determined by the USGS central laboratory, using standard analytical methods (Brown and others, 1970; Goerlitz and Brown, 1972; U.S. Environmental Protection Agency, 1974). To be most useful, constituents are reported in milligrams or micrograms of constituent per kilogram of dry bottom material and as pounds of constituent per cubic yard of bottom material.

Table 5.--Chemical analyses of bottom material

[Mg/kg, milligrams per kilogram; ug/kg, micrograms per kilogram; lb/yd^3, pounds per cubic yard]

Parameter	Sample identification			
	A (mg/kg)	B (mg/kg)	A (lb/yd^3)	B (lb/yd^3)
Residue, loss on ignition	78,400	77,800	91	90
Chemical oxygen demand	70,000	76,000	81	88
Total organic carbon	23,000	23,000	27	27
Total phosphorus, as P	270	60	.31	.07
Kjeldahl nitrogen, as N	1,320	1,490	1.5	1.7
Nitrate plus nitrite nitrogen, as N	0	0	0	0
Nitrite nitrogen, as N	0	0	0	0
Nitrate nitrogen, as N	0	0	0	0
Ammonia nitrogen, as N	170	260	.20	.31
Arsenic	5	5	6×10^{-3}	6×10^{-3}
Cadmium	< 1	< 1	$<1.2 \times 10^{-3}$	$<1.2 \times 10^{-3}$
Total chromium	14	14	.02	.02
Cobalt	15	15	.02	.02
Copper	31	31	.04	.04
Cyanide	180	170	.21	.20
Iron	17,000	16,000	20	19
Lead	40	35	.05	.04
Manganese	460	520	.53	.60
Mercury	.11	.11	1.3×10^{-4}	1.3×10^{-4}
Nickel	15	15	.02	.02
Selenium	0	0	0	0
Zinc	87	85	.10	.099
Phenol	.25	.54	2.9×10^{-4}	6.2×10^{-4}

Table 5.--Chemical analyses of bottom material--Continued

Parameter	Sample identification A (ug/kg)	B (ug/kg)	A (lb/yd^3)	B (lb/yd^3)
Aldrin	2.0	7.0	$2.3x10^{-6}$	$8.1x10^{-6}$
Chlordane	8.0	10	$9.3x10^{-6}$	$1.2x10^{-5}$
DDD	4.6	6.7	$5.3x10^{-6}$	$7.8x10^{-6}$
DDE	3.7	7.5	$4.3x10^{-6}$	$8.7x10^{-6}$
DDT	2.7	1.4	$3.1x10^{-6}$	$1.6x10^{-6}$
Diazinon	0	1.0	0	$1.2x10^{-6}$
Dieldrin	1.0	2.1	$1.2x10^{-6}$	$2.4x10^{-6}$
Endosulfan (thiodane)	0	0	0	0
Endrin	0	0	0	0
Ethyl parathion	0	0	0	0
Ethyl triesteline (trithion)	0	0	0	0
Ethion	0	0	0	0
Heptachlor	0	0	0	0
Heptachlor expoxide	0	0	0	0
Lindane	.8	0	$9.3x10^{-7}$	0
Malathion	0	0	0	0
Methoxychlor	6.1	9.0	$7.1x10^{-6}$	$1.0x10^{-5}$
Methyl parathion	0	0	0	0
Methyl trithion	0	0	0	0
Polychlorinated biphenyls (PCB)	51	57	$5.9x10^{-5}$	$6.6x10^{-5}$
Polychlorinated napthalenes (PCN)	0	0	0	0

REFERENCES CITED

American Public Health Association and others, 1975, Standard methods for the examination of water and waste water [14th ed.]: Washington, D. C., Am. Public Health Assoc., 1193 p.

Brown, Eugene, Skougstad, M. W., and Fishman, M. J., 1970, Methods for collection and analysis of water samples for dissolved minerals and gases: U.S. Geol. Survey Techniques Water-Resources Inv., book 5, chap. A1, 160 p.

Goerlitz, D. F., and Brown, Eugene, 1972, Methods for analysis of organic substances in water: U.S. Geol. Survey Techniques Water-Resources Inv., book 5, chap. A3, 40 p.

Guy, H. P., 1969, Laboratory theory and methods for sediment analysis: U.S. Geol. Survey Techniques Water-Resources Inv., book 5, chap. C1, 58 p.

Hines, W. G., McKenzie, S. W., Rickert, D. A., and Rinella, F. A., 1977, Dissolved-oxygen regimen of the Willamette River, Oregon, under conditions of basinwide secondary treatment: U.S. Geol. Survey Circ. 715-I (in press).

U.S. Environmental Protection Agency, 1974, Methods for chemical analysis of water and wastes: Cincinnati, Ohio, Natl. Environmental Research Center, 298 p.