Characteristics of Effluents from Large Municipal Wastewater Treatment Facilities in 1993

Effluents from the Hyperion Treatment Plant (HTP) of the City of Los Angeles, the Joint Water Pollution Control Plant (JWPCP) of County Sanitation Districts of Los Angeles County (CSDLAC), Wastewater Treatment Plants 1 and 2 of County Sanitation Districts of Orange County (CSDOC), and Point Loma Wastewater Treatment Plant (PLWTP) of the City of San Diego comprise 90% of municipal wastewater discharged directly to the Southern California Bight (Figure 1). These agencies have routinely measured the characteristics of their effluents for at least two decades. Each year during this period, the Southern California Coastal Water Research Project (SCCWRP) has summarized these measurements and reported on discharge and constituent trends. In this report, we summarize the concentrations of effluent constituents and estimate the mass emissions for these four agencies for 1993; we also discuss trends in the mass emissions of contaminants from 1971 to 1993.

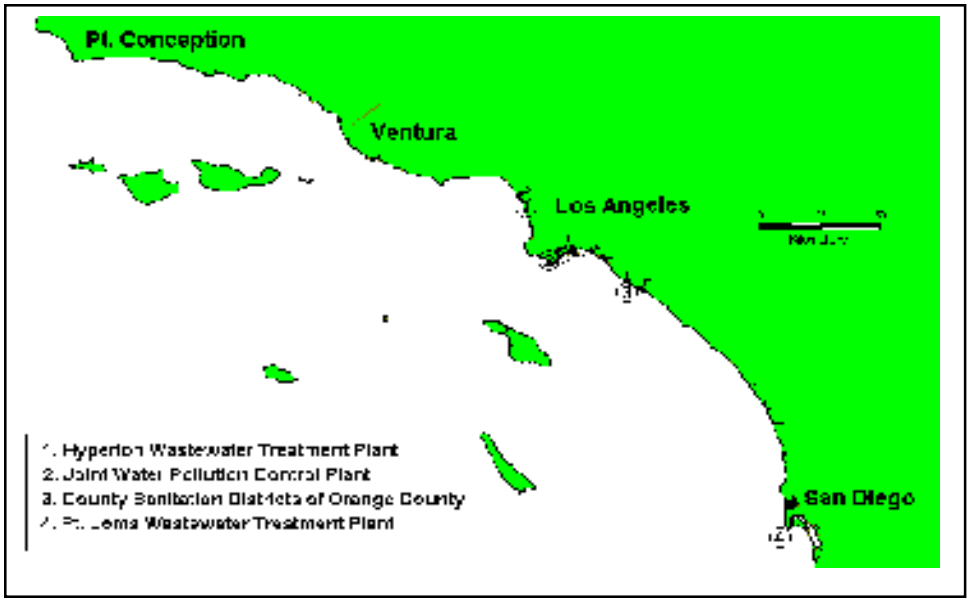
MATERIALS AND METHODS

We obtained the effluent data that are reported monthly and annually by each discharge agency under National Pollution Discharge Elimination System permits from the Los Angeles, Santa Ana, and San Diego Regional Water Quality Control Boards.

Annual contaminant mass emissions were estimated from the product of mean daily flow in month *i*, constituent concentration in month *i*, and the number of days in the month; these were summed over all months to obtain the annual estimate (Appendix 1). Monthly constituent concentrations below method detection limits were treated as zeros in calculations of annual mean constituent concentrations. However, where annual mean concentrations were below detection limits, they were reported as less than the detection limits rather than as zeros (Appendix 1).

Effluent data mass emission estimates for 1990-1992 were based on monthly values of flow and constituent concentrations (SCCWRP 1992, 1994). Prior to 1990, effluent data mass emission estimates were based on annual values. In reports of the 1990-1992 data, annual mass emissions were reported as zero where annual mean constituent concentrations were below method detection limits, even though there may have been measurable concentrations, and hence measurable discharges, in some months. Because these measurable discharges were neglected by this method, the method has been changed. Beginning with this report, 1990-93 mass emissions were calculated from all months with measurable concentrations even though annual mean constituent concentrations may be below detection limits. Months with concentrations below detection limits were considered to have zero mass emissions.

FIGURE 1. Map of the Southern California Bight showing the locations of the four largest municipal wastewater discharges: Hyperion Wastewater Treatment Plant (HTP; City of Los Angeles), Joint Water Pollution Control Plant (JWPCP; County Sanitation Districts of Los Angeles County), County Sanitation Districts of Orange County (CSDOC), and Point Loma Wastewater Treatment Plant (PLWTP; City of San Diego).



RESULTS

The four largest agencies generally discharge municipal wastewater into the ocean at a depth of about 60 m via outfalls (Table 1). However, the Point Loma outfall was recently extended to a depth of 93 m and began discharging on November 24, 1993. Daily flow rates varied among the dischargers by a factor of about two in 1993. The amount of secondary treated water ranged from zero (PLWTP) to 59% (JWPCP).

The concentrations of effluent constituents generally varied by a factor of two among the four municipal wastewater treatment plants; a few constituents (selenium, total phenols, and nonchlorinated phenols) varied by more than an order of magnitude (Table 2). Differences among the effluents were due to the type of wastes (domestic and industrial), source control, volume of water removed for reclamation and inland discharge, and the efficiency and degree of treatment (advanced primary or secondary).

The monthly concentrations of some constituents varied substantially at individual treatment plants (Table 2). Twenty-three percent of the mean monthly constituent concentrations above detection limits had coefficients of variation higher than 50%. Coefficients of variation higher than 100% generally were due to a high proportion of monthly contaminant concentrations below detection limits.

Detectable levels of monthly concentrations of DDT were reported by HTP (eight months), JWPCP (nine months), and CSDOC (one month). However, because most of the concentrations were near detection limits the annual mean concentrations of DDT were below detection limits. Monthly and annual mean concentrations of PCB were below detection limits for all dischargers.

Effluent mass emissions from the four dischargers were usually related to flow (Table 3); the average rank correlation (r_s) between constituent mass emissions and flow for the four treatment plants was 0.57. JWPCP had the highest annual constituent mass emissions but ranked second in flow (2×10^9 L or 0.4% less than HTP).

DISCUSSION

Comparison of 1992 and 1993 Effluents

The combined daily volume of effluent discharged from the four largest municipal wastewater treatment facilities in Southern California increased by 3% from 1992 to 1993 (Table 1; Figure 2). Daily flow increased 9% at HTP, 5% at PLWTP, and 2% at CSDOC, and decreased 2% at JWPCP. The proportion of combined effluent receiving secondary treatment decreased from 46% in 1992 to 44% in 1993. The greatest decrease occurred at CSDOC where 49% of the flow received secondary treatment in 1993, down from 55% in 1992.

From 1992 to 1993, the concentrations of 58% of the effluent constituents declined, 24% were unchanged, and 18% increased (SCCWRP 1994). Suspended solids concentrations decreased an average of 9%; PLWTP had the greatest decrease (24%). Biochemical oxygen demand (BOD) concentrations decreased an average of 2% and oil and grease concentrations decreased an average of 8%. Sixty three percent of the metal concentrations decreased, 23% stayed the same, and 14% increased. CSDOC had the greatest number of metals (nine out of 10) that decreased.

TABLE 1. Volume of municipal wastewater discharged to the ocean by the largest municipal wastewater treatment facilities in Southern California in 1992 and 1993.

			1992			1993		
Treatment Plant	Length of Outfalls From Shore (m)	Depth of Discharge (m)	Advanced Primary (mgd[a])	Secondary (mgd)	Total Flow (mgd)	Advanced Primary (mgd)	Secondary (mgd)	Total Flow (mgd)
HTP[b]	8,300	57	141	162	303	164	166	330
JWPCP[c]	2,800/3,600	60	137	196	333	133	195	328
CSDOC[d]	7,250	60	101	123	224	116	113	229
PLWTP[e]			179	0	179	188	0	188
Jan 1-Nov 23	3,600	60						
Nov 24-Dec 31	7,285	93						
Total			558	481	1039	601	474	1075

[a] mgd=million gallons per day (1 mgd = 3,785,000 L/day).
[b] HTP=Hyperion Treatment Plant, Department of City of Los Angeles.
[c] JWPCP=Joint Water Pollution Control Plant, County Sanitation Districts of Los Angeles County.
[d] CSDOC=County Sanitation Districts of Orange County.
[e] PLWTP=Point Loma Wastewater Treatment Plant, Department of Water Utilities, City of San Diego.

Annual mean concentrations of total DDT and PCBs were below detection limits in both years. Effluent acute toxicity to fathead minnows (*Pimephales promelas*) increased 18% at HTP, but decreased 40% at JWPCP, 9% at CSDOC, and 7% at PLWTP.

Mass emissions of the major effluent constituents declined by 14% (MBAS excluded) from 1992 to 1993 (Table 4). The combined emissions of suspended solids decreased 5% from 1992 to 1993, BOD increased less than 1%, and oil and grease decreased 5%. The discharge of suspended solids increased slightly at HTP, but decreased 1**%** at JWPCP, 4% at CSDOC, and 18% at PLWTP. BOD increased 8% at HTP and 5% at CSDOC, but decreased 4% at JWPCP and 5% at PLWTP. The mass emission of oil and grease increased 3% at HTP, but decreased 1% at CSDOC, 9% at PLWTP, and 18% at JWPCP.

The combined emissions of all trace metals decreased 13% from 1992 to 1993 (Table 4; SCCWRP 1994). Combined emissions decreased for lead (47%), chromium (38%), mercury (33%), zinc (16%), silver (13%), selenium (8%), copper (6%), and arsenic (5%). Although the percentage of combined emissions of cadmium increased 20%, the actual amount of emissions have only increased

TABLE 2. Means and coefficients of variation (CV) of annual constituent concentrations in effluents from the largest municipal wastewater treatment facilities in Southern California in 1993.

	HTP[a]		JWPCP[b]		CSDOC[c]		PLWTP[d]	
Constituent	Mean	CV(%)	Mean	CV(%)	Mean	CV(%)	Mean	CV(%)
Flow (mgd)[e]	330	4	328	3	229	4	188	11
Flow (million L/day)	1249	4	1241	3	867	4	712	11
Suspended solids (mg/L)	35	30	69	8	43	5	55	41
Settleable solids (ml/L)	0.1	49	0.3	56	0.6	16	0.3	110
BOD (mg/L)	82	14	96	6	78	5	118	15
Oil and grease (mg/L)	11	13	11	12	14.2	10	14.4	23
Nitrate-N (mg/L)	0.18	68	0.29	41	-	-	0.09[f]	78
Nitrite-N (mg/L)	-	-	0.16	63	-	-	-	-
Ammonia-N (mg/L)	23.6	7	34.9	8	24	5	26.9	13
Organic N (mg/L)	5.52	8	6.55	9	-	-	-	-
Phosphate (mg/L)[f]	-	-	-	-	-	-	1.4	43
Total phosphorus (mg/L)	4.44	15	4.23	10	-	-	-	-
Cyanide (µg/L)	23	105	<10	-	<20	-	4.4	45
Turbidity NTU[g]	27	32	53	10	40	7	59	18
Toxicity TU_a[h]	1.79	21	0.84	71	0.70	60	1.30	11
Silver (µg/L)	5.2	39	6	37	2.6	20	<6.6	-
Arsenic (µg/L)	6.3	37	3	18	1.2	72	2.9	40
Cadmium (µg/L)	<1	-	<1	-	0.8	41	<4.5	-
Chromium (µg/L)	4	115	<10	-	5	21	<9.1	-
Copper (µg/L)	29	20	24	15	33	12	38	66
Mercury (µg/L)	<0.1	-	<0.5	-	<0.2	-	<0.5	-
Nickel (µg/L)	15	100	39	17	21	14	<15	-
Lead (µg/L)	<2	-	<8	-	2	50	<18	-
Selenium (µg/L)	<1	-	13	15	<1	-	1.4	26
Zinc (µg/L)	41	19	86	36	45	13	38	31
Phenols (µg/L)[i]	31	34	436	26	45	68	-	-
Chlorinated[j]	<7[k]	-	<16[k]	-	<1.3[k]	-	<3.6[k]	-
Nonchlorinated[j]	2.62	67	150	71	3.9	37	8.3	59
Total DDT (µg/L)	<0.013[k]	-	<0.03[k]	-	<0.02[k]	-	<0.04[k]	-
Total PCB[l] (µg/L)	<0.065[k]	-	<0.9[k]	-	<0.5[k]	-	<0.6[m]	-

The number of significant figures are those reported by the agencies.
[a]Hyperion Treatment Plant, City of Los Angeles.
[b]Joint Water Pollution Control Plant, County Sanitation Districts of Los Angeles County.
[c]County Sanitation Districts of Orange County.
[d]Point Loma Wastewater Treatment Plant, City of San Diego.
[e]mgd=million gallons per day (1 mgd = 3,785,000 L/day).
[f]Only soluble forms of phosphate and nitrate were analyzed.
[g]NTU=nephelometric turbidity units.
[h]TUa (toxic units acute)= 100/96 hr LC 50%.
[i]EPA method 420.2 (Colorimetric method).
[j]EPA method 604 or 625 (GC/MS method).
[k]Maximum of the range of detection limits reported.
[l]Total PCB= PCB 1016, 1221, 1232, 1242, 1248, 1254, and 1260.
[m]PCB 1221, 1232, 1248, and 1254 detection limits were not determined.

0.1 mt. Nickel emissions remained unchanged from 1992 to 1993.

The combined emissions of DDT decreased 29% from 1992 to 1993 (Table 4) (SCCWRP 1994). For both years, the annual mean concentrations were below method detection limits; nevertheless there were still monthly concentrations that were measurable and these contributed to the mass emissions. All four dischargers had monthly concentrations of PCBs below detection limits in 1992 and 1993.

Effluent Trends, 1971-1993

The combined flow from the four largest municipal wastewater treatment facilities increased 16% from 1971 to 1993 (Figure 2), for a mean annual increase of 0.7% (sd=3.4, n=22). During this time, the volume of wastewater discharged by CSDOC and PLWTP doubled while the volume discharged by JWPCP decreased 12% and the volume discharged by HTP decreased 1%. Population growth patterns, industry type and number, water reclamation, and inland discharge accounted for differences among the districts. Los Angeles County has grown by approximately two million people since 1970, Orange County and San Diego County each have grown by approximately one million (SCCWRP 1973, California Department of Finance 1994). CSDLAC and the City of Los Angeles have expanded their upstream treatment and reclamation facilities. JWPCP reclaimed 147 mgd of water in 1993—double the amount reclaimed 13 years ago (71 mgd). The volume of effluent discharged to the Los Angeles River by the Los Angeles-Glendale and Donald C. Tillman Water reclamation plants increased from 25 mgd in 1985 to 73 mgd in 1993 (City of Los Angeles 1994a,b).

The annual combined volume of effluent discharged increased for the first time in 1993 since 1989 (Table 4). The lower volumes discharged from 1990 to 1992 may be the result of water conservation during the drought,

TABLE 3. Estimated constituent mass emissions from the largest municipal wastewater treatment facilities in Southern California in 1993.

Constituent	HTP[a]	JWPCP[b]	CSDOC[c]	PLWTP[d]	Total
Flow[e] (L x 10^9)	456	454	316	259	1,485
Suspended solids (mt[f])	15,704	31,064	13,704	14,739	75,211
BOD (mt)	37,414	43,446	24,717	30,432	136,009
Oil and grease (mt)	4,964	5,004	4,475	3,700	18,143
Nitrate-N (mt)	79	133	-	24	236
Nitrite-N (mt)	-	72	-	-	72
Ammonia-N (mt)	10,754	15,841	7,512	6,912	41,019
Organic N (mt)	2,513	2,969	-	-	5,482
Phosphate (mt)	-	-	-	372	372
Total phosphorus (mt)	2,025	1,920	-	-	3,945
Cyanide (mt)	11	2.0	-	1.1	14
Silver (mt)	2.4	2.7	0.8	0.1	6.0
Arsenic (mt)	2.8	1.2	0.4	0.8	5.2
Cadmium (mt)	0.2	0.2	0.2	0.04	0.6
Chromium (mt)	1.8	3.2	1.6	0.2	6.8
Copper (mt)	14	11	10	9.7	45
Mercury (mt)	-	-	-	0.02	0.02
Nickel (mt)	6.7	18	6.5	0.2	31
Lead (mt)	0.07	1.1	0.5	0.1	1.8
Selenium (mt)	0.1	6.0	0.1	0.4	6.6
Zinc (mt)	19	39	14	9.9	82
Phenols[g] (mt)	14	197	14	-	225
Chlorinated[h]	-	2.6	-	-	2.6
Nonchlorinated[h]	1.2	69	1.2	2.1	74
Total DDT[i] (kg)	2.3	6.4	0.5	-	9.2
Total PCB[i] (kg)	-	-	-	-	-

[a] Hyperion Treatment Plant, City of Los Angeles.
[b] Joint Water Pollution Control Plant, County Sanitation Districts of Los Angeles County.
[c] County Sanitation Districts of Orange County.
[d] Point Loma Wastewater Treatment Plant, City of San Diego.
[e] Annual flow volumes were the sum of mean daily flow per month times the number of days in each month.
[f] mt=metric tons.
[g] EPA method 420.2 (Colorimetric method).
[h] EPA method 604 or 625 (GCMS method).
[i] Total PCB= PCB 1016, 1221, 1232, 1242, 1248, 1254, and 1260.

increased water reclamation, or a decline in manufacturing, especially in the defense industry.

Despite increases in population and the volume of wastewater discharged during the past 23 years, the mass emissions of most effluent constituents have declined (Table 4). The combined mass emissions have decreased for suspended solids (74%), BOD (52%), and oil and grease (71%) (Figures 3-5). The decline in JWPCP solids emissions between 1971 and 1993 accounted for 71% of the reduction (SCCWRP 1973). Termination of sludge discharge from the HTP 7-mile outfall (November 1987) accounted for a 40% reduction in combined solids emissions from 1987 to 1988.

FIGURE 2. Combined effluent flow and individual effluent flows from the four largest municipal wastewater treatment facilities in Southern California (MGD = millions of gallons per day. L = liters).

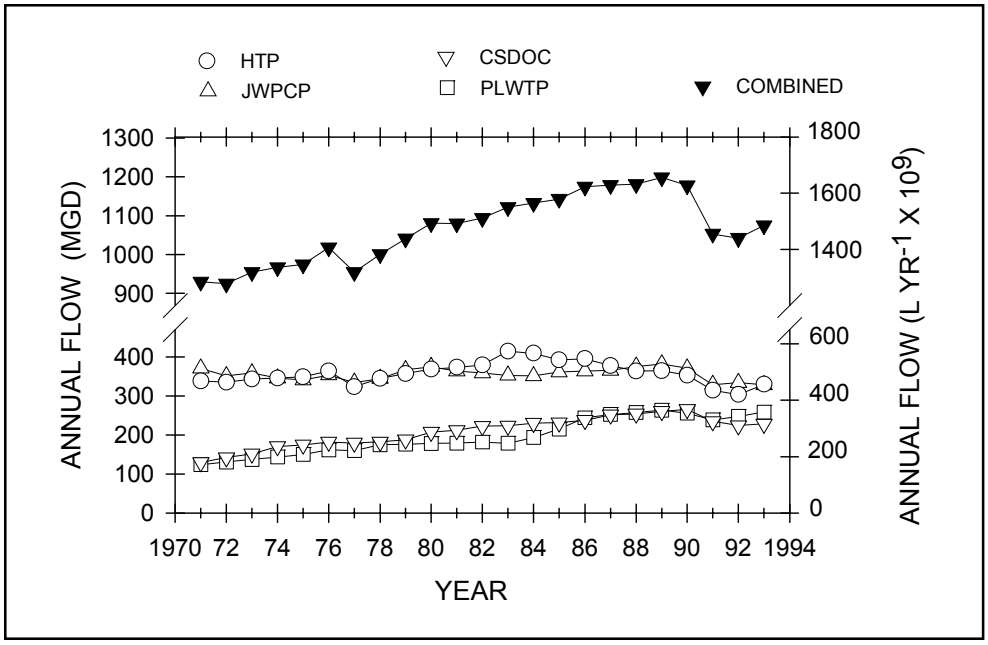
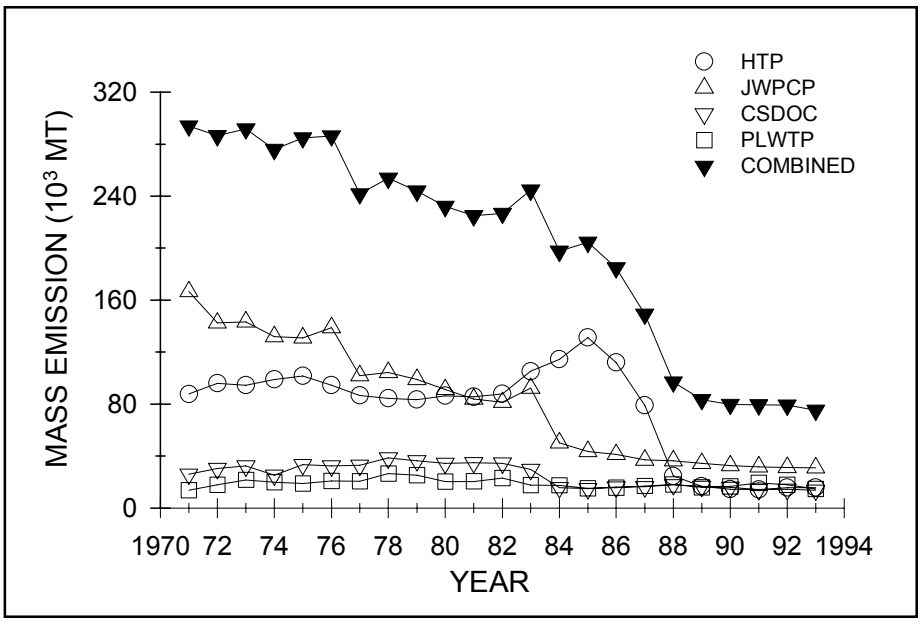


TABLE 4. Estimated combined constituent mass emissions for City of Los Angeles Hyperion Treatment Plant, County Sanitation Districts of Los Angeles County Joint Water Pollution Control Plant, County Sanitation Districts of Orange County Wastewater Treatment Plants 1 and 2, and City of San Diego Point Loma Wastewater Treatment Plant from 1971 through 1993.

Constituent	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Flow (L x 10^9)	1,284	1,278	1,319	1,336	1,346	1,406	1,319	1,382	1,438	1,493	1,492
Flow (mgd)[a]	930	922	954	967	975	1,015	955	1,001	1,041	1,078	1,080
Suspended solids[b] (mt[c] x 10^3)	294	287	292	271	285	286	242	254	244	232	225
BOD[d] (mt x 10^3)	283	250	227	234	234	256	242	234	242	255	261
Oil and grease (mt x 10^3)	62	61	61	55	57	59	49	49	45	38	37
NH_3-N (mt x 10^3)	55	40	46	39	36	37	40	39	41	41	41
Total P[e](mt x 10^3)	34	36	39	38	11	23	11	10	10	10	9.5
MBAS[f] (mt x 10^3)	6.5	6.3	5.9	6.8	6.1	6.1	5.4	5.8	6.3	6.4	5.6
Cyanide (mt)	188	238	244	303	251	401	213	176	145	116	98
Silver (mt)	15	22	29	22	25	20	34	32	43	30	28
Arsenic (mt)	3[h]	18	16	18	12	11	12	15	15	11	12
Cadmium (mt)	52	34	49	55	51	44	41	44	43	39	32
Chromium (mt)	667	675	694	690	579	592	368	279	239	275	187
Copper (mt)	535	486	508	576	510	506	402	416	361	335	337
Mercury (mt)	2.9	2.6	3.1	1.8	2.2	2.5	2.6	1.9	2.6	1.8	1.8
Nickel (mt)	326	262	318	315	282	302	262	318	256	224	167
Lead (mt)	226	252	180	199	198	189	150	216	224	175	130
Selenium (mt)	12	11	16	18	11	22	22	23	7.9	11	15
Zinc (mt)	1,834	1,201	1,189	1,324	1,087	1,061	834	833	7287	729	538
DDT_i (kg)	21,527	6,558	3,818	1,562	1,158	1,633	855	1,121	839	671	480
PCB_i (kg)	8,730	9,830	3,389	5,421	3,065	3,492	2,183	2,540	1,170	1,127	1,252

[a]mgd=million gallons per day (1 mgd = 3,785,000 L/day).
[b]Solids from Hyperion 7-mile outfall are total solids.
[c]mt=metric tons.
[d]Hyperion 7-mile outfall not included.
[e]Sum of soluble phosphate (PLWTP) and total phosphorus (HTP and JWPCP).
[f]MBAS = methylene blue active substances.
[g]Analyses discontinued.

FIGURE 3. Combined suspended solids emissions and individual suspended solids from the four largest municipal wastewater treatment facilities in Southern California (MT = metric tons).



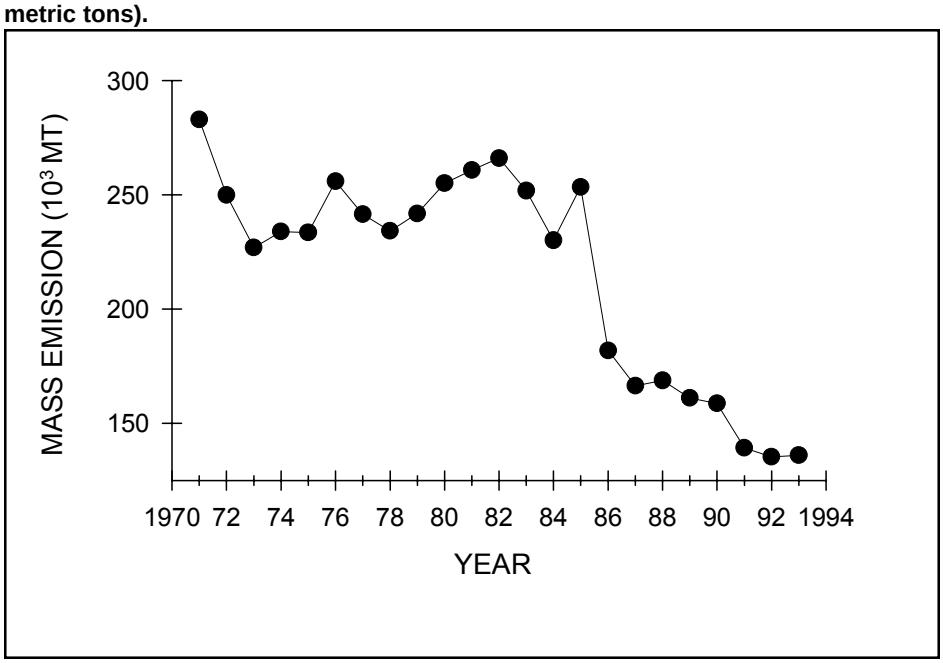
Most of the decline in BOD occurred after 1985. Reductions by JWPCP from 1971 to 1993 accounted for about 70% of the decline in oil and grease (SCCWRP 1973).

The combined mass emission of trace metals declined 95% from 1971 to 1993 (Table 4; Figure 6). Declines of individual metals averaged 87% (sd=20, n=9, arsenic excluded). Arsenic was reported only by HTP in 1971. The greatest reductions were for cadmium, chromium, mercury and lead (all 99%), followed by zinc (96%), copper (92%), and nickel (90%). From 1972 to 1993, arsenic declined 71%. The combined mass emissions of trace metals declined 36% from 1987 to 1988; the termination of sludge discharge from the HTP 7-mile outfall accounted for about 60% of the decline. From 1989 to 1991, combined metal emissions decreased 31%; however, lead decreased 91%. Some of the lead decline is due to the change in methods by HTP and CSDOC from flame atomic absorption spectrophotometry (AAS) to graphite furnace AAS, which has less sample matrix interference. Matrix interference causes some of the matrix to appear as lead, leading to an overestimate of lead concentration.

1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1,511	1,549	1,565	1,579	1,623	1,629	1,632	1,656	1,627	1,455	1,440	1,485
1,094	1,122	1,129	1,143	1,175	1,179	1,178	1,199	1,178	1,053	1,039	1,075
227	245	198	205	185	149	97	83	80	79	79	75
266	252	230	254	182	167	169	161	159	139	135	136
37	36	30	34	29	26	25	23	22	19	19	18
42	40	40	43	45	44	44	45	46	44	42	41
9.0	9.0	9.2	8.5	11	9.0	7.1	6.9	7.1	6.7	5.9	4.3
5.7	5.2	4.6	4.3	4.8	4.6	3.4	3.3	3.5	3.5	3.2	-[g]
77	46	39	26	22	27	26	10	13	16	18	14
25	26	24	26	22	15	11	11	9.4	7.9	6.9	6
8	10	18	16	12	12	8.9	7.4	8.2	5.4	5.5	5.2
21	23	16	16	14	9.0	3.4	1.9	1.3[i]	1.1[i]	0.5	0.6
203	163	140	110	88	57	29	22	14	10	11	6.8
284	272	251	239	202	125	76	68	59	47	48	45
1.2	1.1	0.9	0.9	0.7	0.4	0.4	0.4	0.2	0.2	0.03[j]	0.02
168	163	133	118	127	76	63	54	40	33	31	31
122	98	87	118	105	61	50	27	8.0[i]	2.5[i]	3.4[i]	1.8
6.4	6.5	6.5	5.8	8.2	7.2	6.7	7.6	7.3	7.0[i]	7.2[i]	6.6
545	497	369	375	336	261	151	146	115	125	98	82
290	223	310	48	51	53	26	20	17[i]	6.4[i]	13[i]	9.2
785	628	1,209	46	37	5	-[k]	-[k]	-[k]	-[k]	-[k]	-[k]

[h]Only Hyperion data were available.
[i]Revised numbers. In past, if the annual mean concentration was below the method detection limit, the mass emission was recorded as missing; mass emissions herein were calculated only from months with measurable concentrations. Months with nondetectable concentrations were considered to have zero mass emissions (see Appendix).
[j]Estimates for 1971 through 1975 were based on SCCWRP analyses of effluents; estimates for years after 1975 were based on discharger data.
[k]Concentrations were below method detection limits.

FIGURE 4. Combined mass emission of biochemical oxygen demand from the four largest municipal wastewater treatment facilities Southern California (MT = metric tons).



total and long-term trends of mass emissions into the Southern California Bight.

The interpretation of long-term trends was also hindered somewhat by the questionable reliability of trace contaminant analyses (particularly organic) in the early years of monitoring programs. Analytical methods for quantifying chlorinated hydrocarbons evolved in the 1970s and techniques had not yet been standardized among laboratories. The older data reported herein were the best available for past discharges, but better methods are used today. The accuracy and precision of contaminant analyses have improved over the years because of advancements in methods and instruments, and because of intercalibration among laboratories.

The combined emissions of chlorinated hydrocarbons declined more than 99% from 1971 to 1993 (Table 4; Figure 7). Montrose Chemical Corporation, the largest manufacturer of DDT in the world and the only manufacturer in California, discharged DDT wastes into the JWPCP sewer system from 1947 to 1971 (Chartrand 1988). Residual sediment in the sewer system was the principal source of DDT in JWPCP effluent after that time. Annual mean concentrations of DDT were below detection limits in 1993; however, JWPCP (as well as HTP and CSDOC) still have measurable amounts of DDT in their effluents in some months.

Recent declines in constituent concentrations and mass emissions were the result of improved primary treatment, increased secondary treatment, and improved source control (the most important factor). As a consequence, the number of reported analytes with concentrations below detection limits continued to increase. If detection limits of the recommended techniques were below discharge NPDES permit requirements, the constituents were in compliance. However, results below detection limits complicated the assessment of

CONCLUSIONS

The quality of municipal wastewaters discharged to the Southern California Bight has improved significantly over the past two decades. Decreases in contaminant mass emissions are the result of increased source control and land disposal of sludge, improved sludge and primary treatment, and increased secondary treatment. In the future, rates of improvement in mass emissions from the

FIGURE 5. Combined oil and grease emissions and individual oil and grease from the four largest municipal wastewater treatment facilities in Southern California (MT = metric tons).

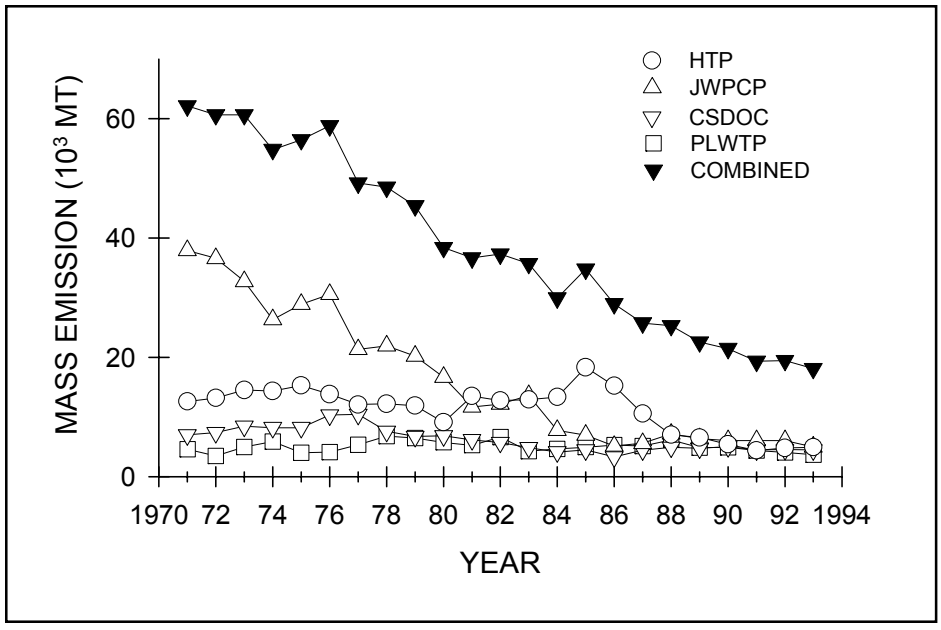
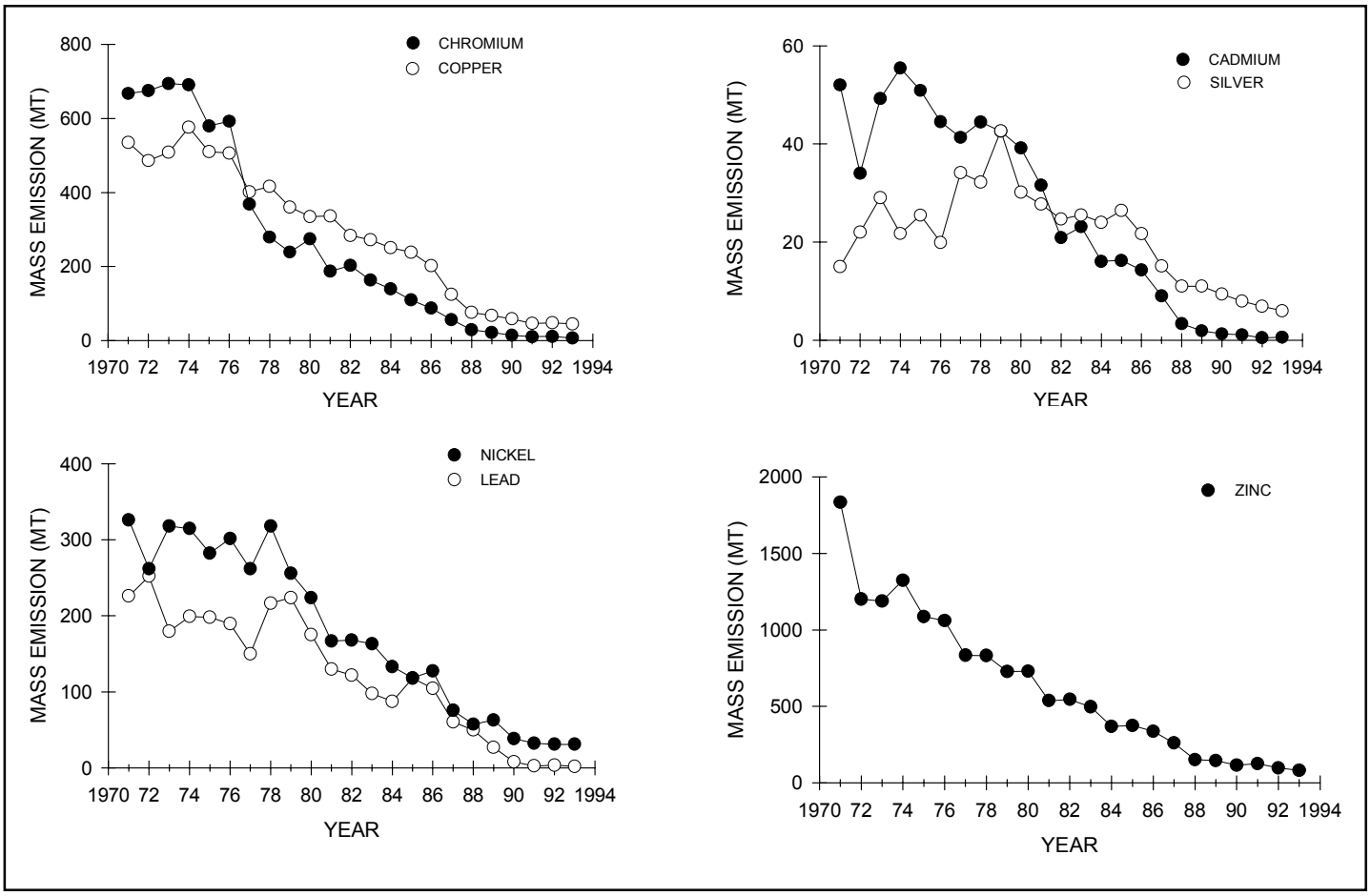


FIGURE 6. Combined mass emissions of trace metals from the four largest wastewater treatment facilities in Southern California (MT = metric tons).



major municipal wastewater treatment facilities are not likely to be as great as in the past. Nominal reductions will occur due to planned increases in the volume of wastewater receiving secondary treatment, increased inland reclamation of water, and more effective source control.

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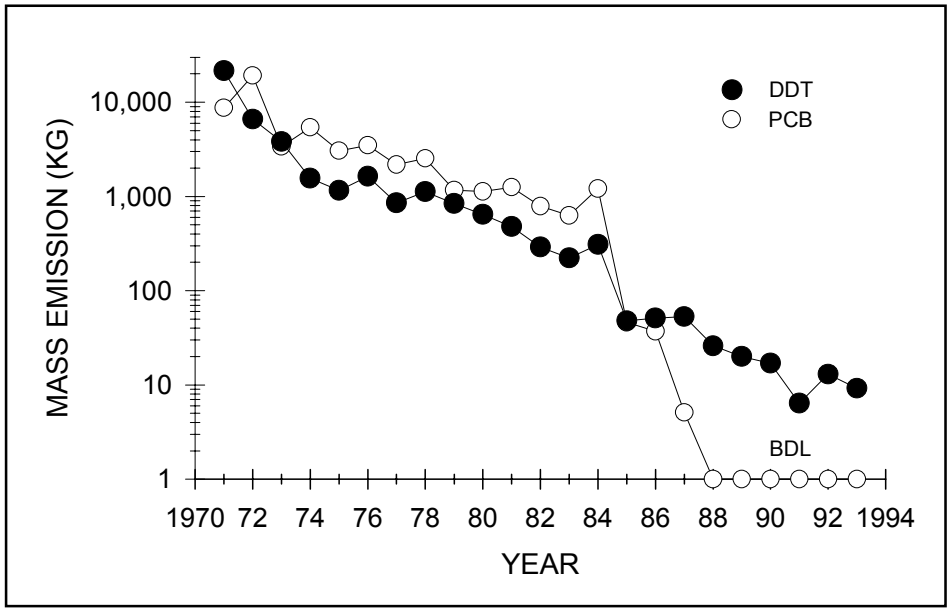
FIGURE 7. Combined mass emissions of chlorinated hydrocarbons from the four largest wastewater treatment facilities in Southern California (BDL = below detection limits).



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APPENDIX

Mass Emission Estimation

Annual constituent mass emissions (ME) were estimated from:

$$ME = \sum_{i=1}^{12} (F_i C_i D_i)$$

where

F_i = mean daily flow in month *i*;
C_i = constituent concentration in month *i*; and
D_i = number of days in month *i*.

This method, which was first used for 1990 effluent data (SCCWRP 1992), differs from previous SCCWRP reports where mass emissions were estimated by the product of total annual flow and mean annual constituent concentration (e.g., SCCWRP 1990). Estimates by the two methods differ by <1%; therefore, the historic mass emission data have not been recalculated.

Monthly constituent concentrations below detection limits were treated as zeros in the calculation of annual mean concentrations. If the annual mean was below the detection limit, it was reported as less than the detection limit in the table of concentrations (Table 2). Months with constituent concentrations below detection limits were considered to have zero mass emissions. However, if the constituent was above the detection limit in one or more months, the mass emission for the month(s) was calculated, summed across all months, and included in the table of mass emissions (Table 3).