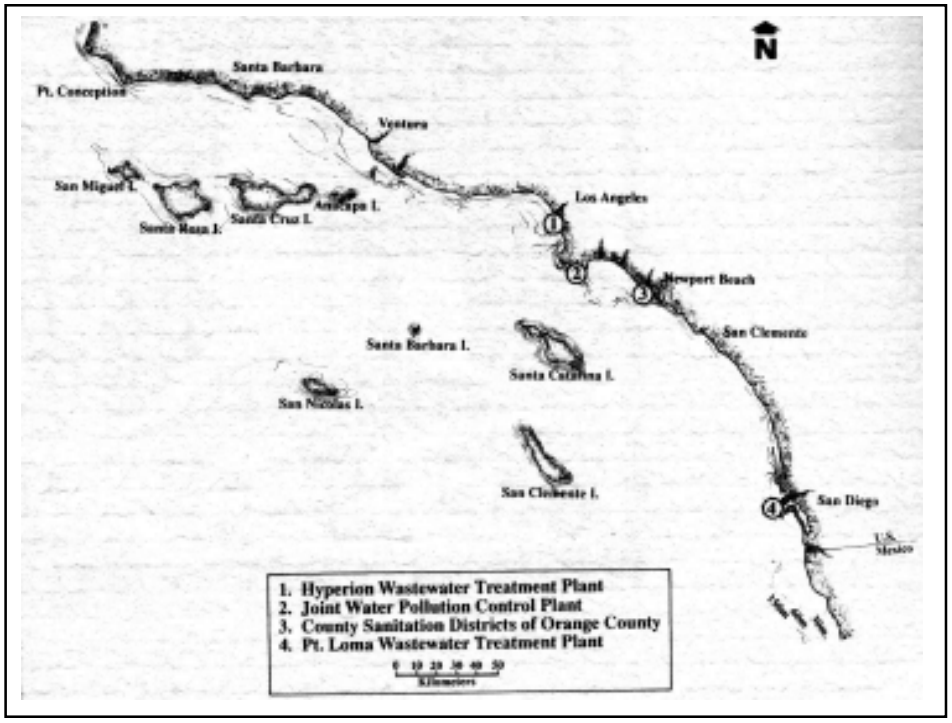
Characteristics of Effluents from Large Municipal Wastewater Treatment Facilities in 1992

In this report, we summarize concentrations of effluent constituents and estimates of effluent mass emissions for 1992 for Hyperion Wastewater Treatment Plant (City of Los Angeles), Joint Water Pollution Control Plant (JWPCP) of the County Sanitation Districts of Los Angeles County, County Sanitation Districts of Orange County Wastewater (CSDOC) Treatment Plants 1 and 2, and Point Loma Sewage Treatment Plant (City of San Diego) (Figure 1). Effluents from these facilities composed 90% of municipal effluents discharged directly to the Southern California Bight (SCB). The discharge agencies have measured the constituents featured in this report for at least two decades. The trends in the mass emission of contaminants from 1971 to 1992 are also discussed.

Figure 1.
Map of the Southern California Bight showing the location of the four largest municipal wastewater dischargers: 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).



Materials and Methods

We obtained the effluent data that are reported monthly and annually by each discharge agency under National Pollution Discharge Elimination System (NPDES) permits to 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). Constituent concentrations below detection limits were treated as zeros.

Results

The combined daily volume of effluent discharged from the four largest municipal wastewater treatment facilities in Southern California declined slightly (1%) from 1991 to 1992 (Table 1; Figure 2); daily flow increased 1% at JWPCP and 3% at PLWTP,

and decreased 4% at HTP and 5% at CSDOC. The proportion of combined effluent receiving secondary treatment remained about the same from 1991 (47%) to 1992 (46%). The greatest increase occurred at CSDOC where 55% of the flow received secondary treatment in 1992, which was up from 49% in 1991.

The concentrations of effluent constituents generally varied by a factor of two among the four municipal wastewater treatment plants; a few constituents — total phenols, nonchlorinated phenols, and selenium — varied by more than an order of magnitude (Table 2). Differences among the effluents were due to the type of wastes treated (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). More than one-quarter of the mean monthly constituent concentrations 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.

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 0.67. The JWPCP had the highest flow and generally the highest constituent mass emissions.

From 1991 to 1992 (SCCWRP 1992), the concentrations of 40% of the effluent constituents declined, 30% were unchanged, and 30% increased. Effluent acute toxicity to fathead minnows (*Pimephales promelas*) increased 9% at HTP, 26% at CSDOC, and

Table 1.
Volume of municipal wastewater discharged to the ocean from 1991 to 1992 by the largest municipal wastewater treatment facilities in Southern California.

	1991			1992				
	Advanced Primary (mgd[a])	Secondary (mgd)	Total Flow (mgd)	Advanced Primary (mgd)	Secondary (mgd)	Total Flow (mgd)	Length of Outfalls From Shore (m)	Depth of Discharge (m)
HTP[b]	133	182	315	141	162	303	8,300	57
JWPCP[c]	137	193	330	137	196	333	2,800/3,600	60
CSDOC[d]	119	116	235	101	123	224	7,250	60
PLWTP[e]	173	0	173	179	0	179	3,600	60
Total	562	491	1053	558	481	1039		

[a]mgd=million gallons per day (1 mgd = 3,785,000 liters/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

14% at PLWTP, but decreased 12% at JWPCP.

The combined emissions of suspended solids and oil and grease remained about the same from 1991 to 1992 (SCCWRP 1992), but biochemical oxygen demand (BOD) declined 3% (Table 4). The discharge of suspended solids decreased 1% at JWPCP and 8% at PLWTP, but increased 10% at HTP and 1% at CSDOC. The mass emission of oil and grease was unchanged at JWPCP, decreased 7% at PLWTP, and increased 9% at HTP and 1%

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 1992.

CONSTITUENT	HTP[a]		JWPCP[b]		CSDOC[c]		PLWTP[d]	
	Mean	CV(%)	Mean	CV(%)	Mean	CV(%)	Mean	CV(%)
Flow (mgd)[e]	303	3	333	3	224	3	179	4
Flow (million liters/day)	1147	3	1260	3	848	3	678	4
Suspended solids (mg/L)	37	21	68	8	46	7	72	34
Settleable solids (mL/L)	0.2	74	0.2	28	0.6	11	0.5	68
BOD (mg/L)	82	12	98	6	76	5	129	12
Oil and grease (mg/L)	11	8	13	8	15	12	16	23
Nitrate-N (mg/L)	0.25	44	0.22	44	-	-	0.02[f]	224
Nitrite-N (mg/L)	-	-	0.14	48	-	-	-	-
Ammonia-N (mg/L)	25	8	37	10	23	6	32	9
Organic N (mg/L)	5.9	18	7.1	10	-	-	-	-
Phosphate (mg/L)[f]	-	-	-	-	-	-	3.8	33
Total phosphorus (mg/L)	5.17	19	6.00	14	-	-	-	-
MBAS[g] (mg/L)	-	-	3.4	48	-	-	6.8	12
Cyanide (µg/L)	28	161	10	97	<20	-	5	34
Phenols (µg/L)[h]	34	75	520	32	20	74	-	-
Nonchlorinated[i]	5	58	235	57	4	99	4	31
Chlorinated[i]	<2-<7	-	10	81	<0.16-<10	-	<2.7-<3.6	-
Turbidity NTU[j]	33	12	53	7	39	3	71	20
Toxicity TU[k]	1.52	31	1.39	43	0.77	48	1.40	12
Silver (µg/L)	7	48	6	48	5	47	<10	-
Arsenic (µg/L)	5	13	4	23	3	29	3	37
Cadmium (µg/L)	1	234	<1	-	1	53	<5	-
Chromium (µg/L)	5	47	15	76	8	28	<50	-
Copper (µg/L)	36	27	25	17	37	7	36	52
Mercury (µg/L)	<0.1	-	<0.5	-	<0.2	-	<0.5	-
Nickel (µg/L)	13	31	37	15	26	14	<40	-
Lead (µg/L)	2	104	<8	-	3	70	<50	-
Selenium (µg/L)	<1	-	14	9	1	115	2	31
Zinc (µg/L)	67	53	80	17	49	20	74	63
Total DDT (µg/L)	<0.003-<0.013	-	<0.01-<0.02	-	<0.004-<0.2	-	<0.02-<0.04	-
Total PCB[l] (µg/L)	<0.025-<0.065	-	<0.08-<0.9	-	<0.5	-	<0.07-<0.6[m]	-

[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
[f]Only soluble forms of phosphate and nitrate are analyzed.
[g]MBAS=methylene blue active substances
[h]EPA method 420.2 (Colorimetric method)
[i]EPA method 604 or 625 (GC/MS method)
[j]NTU=nephelometric turbidity units
[k]TUa (toxic units acute)= 100/96 hr LC 50%
[l]Total PCB= PCB 1016, 1221, 1232, 1242, 1248, 1254, and 1260 with the exception of JWPCP: Total PCB= PCB 1242, 1254, and 1260
[m]PCB 1221, 1232, 1248 and 1254 detection limits have not been determined

at CSDOC. The BOD decreased 4% at HTP and PLWTP, and 3% at JWPCP, and increased 2% at CSDOC.

The combined emissions of trace metals decreased 12% from 1991 to 1992 (Table 4; SCCWRP 1992). There were decreases in the combined emissions of silver (13%), nickel (6%), and zinc (22%). Mercury emissions decreased from 0.2 metric tons (mt) to non-detectable levels. There were increases in the combined emissions of arsenic (2%), cadmium (25%), chromium (10%), copper (2%),

Table 3.

Estimated mass emissions from the largest municipal wastewater treatment facilities in Southern California in 1992.

CONSTITUENTS	HTP[a]	JWPCP[b]	CSDOC[c]	PLWTP[d]	Total
Flow (liters x 10^9)	420	462	310	248	1,440
Suspended solids (mt[e])	15,647	31,256	14,287	17,870	79,060
BOD (mt)	34,575	45,192	23,463	32,137	135,367
Oil and grease (mt)	4,798	6,070	4,539	4,066	19,473
Nitrate-N (mt)	104	101	-	5.6[f]	211
Nitrite-N (mt)	-	63	-	-	63
Ammonia-N (mt)	10,390	17,076	7,148	7,857	42,471
Organic N (mt)	2,490	3,258	-	-	5,748
Phosphate (mt)	-	-	-	954	954
Total phosphorus (mt)	2,169	2,768	-	-	4,937
MBAS[g] (mt)	-	1,554	-	1,694	3,248
Cyanide (mt)	11.8	4.6	-	1.1	17.5
Phenols[h](mt)	14	237	8	-	259
Nonchlorinated[i]	2.0	108	1.1	0.99	112
Chlorinated[i]	-	4.7	-	-	4.7
Silver (mt)	2.8	2.6	1.5	-	6.9
Arsenic (mt)	2.0	1.6	1.1	0.79	5.5
Cadmium (mt)	0.2	-	0.3	-	0.5
Chromium (mt)	1.9	7.0	2.5	-	11.4
Copper (mt)	15	12	12	8.9	48
Mercury (mt)	-	-	-	-	-
Nickel (mt)	5.5	17	8.0	-	31
Lead (mt)	0.6	-	1.0	-	1.6
Selenium (mt)	-	6.4	0.3	0.4	7.1
Zinc (mt)	28	37	15	18	98
Total DDT (kg)	-	-	-	-	-
Total PCB[j](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]mt=metric tons
[f]Only soluble nitrate as N is analyzed
[g]MBAS=methylene blue active substances
[h]EPA method 420.2 (Colorimetric method)
[i]EPA method 604 or 625 (GC/MS method)
[j]Total PCB= PCB 1016, 1221, 1232, 1242, 1248, 1254, and 1260 with the exception of JWPCP: Total PCB= PCB 1242, 1254, and 1260

lead (14%) and selenium (4%) from 1991 to 1992.

Effluent concentrations of DDT and PCB were below method detection limits in 1991 and 1992. Detectable levels of DDT were reported by all dischargers from one (PLWTP) to nine (JWPCP) months, but most concentrations were near detection limits.

Discussion

The annual combined volume of effluent discharged has declined only six times since 1971 (Table 4; SCCWRP 1973). The lower volumes discharged from 1989 to 1992 may be the result of water conservation during the recent drought, increased water reclamation, or a decline in manufacturing, especially in the defense industry. Water reclamation increased 36% in the City of Los Angeles and 6% in Los Angeles County from 1991 to 1992; effluent concentrations remained about the same while mass emissions declined by 6%.

Recent declines in constituent concentrations and mass emissions were the result of improved primary treatment, increased secondary treat-

Table 4.
Combined estimate of mass emissions from 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 1992.

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

[a]mgd=million gallons per day
[b]Solids from Hyperion 7-mile outfall are total solids.
[c]mt=metric tons
[d]Sum of soluble phosphate (PLWTP) and total phosphorus (HTP and JWPCP).

ment, and improved source control (the most important factor). As a consequence, the number of reported analytes with masses below detection limits continued to increase. If detection limits of the recommended techniques are below discharge NPDES permit requirements, the constituents are in compliance. However, results below detection limits complicate the assessment of total and long-term trends of mass emissions into the SCB.

The combined flow from the four largest municipal wastewater treatment facilities increased 12% from 1971 to 1992 (Figure 2), for a mean annual increase of 0.6% (sd=3.5, n=21). During this time, the volume of wastewater discharged by CSDOC and PLWTP doubled while the volume discharged by HTP and JWPCP decreased about 10%. Population growth patterns, water reclamation, and inland discharge account for differences among the districts. Since 1970, the population of Orange County has grown 80% and the population of San Diego County has grown 95%, while the population of Los Angeles County has grown 30% (SCCWRP 1973, California Department of Finance 1992). Los Angeles County and the

1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
1,492	1,511	1,549	1,565	1,579	1,623	1,629	1,632	1,656	1,627	1,455	1,440
1,080	1,094	1,122	1,129	1,143	1,175	1,179	1,178	1,199	1,178	1,053	1,039
225	227	245	198	205	185	149	97	83	80	79	79
261	266	252	230	254	182	167	169	161	159	139	135
37	37	36	30	34	29	26	25	23	22	19	19
41	42	40	40	43	45	44	44	45	46	44	42
9.5	9.0	9.0	9.2	8.5	11	9.0	7.1	6.9	7.1	6.7	5.9
5.6	5.7	5.2	4.6	4.3	4.8	4.6	3.4	3.3	3.5	3.5	3.2
98	77	46	39	26	22	27	26	10	13	16	18
28	25	26	24	26	22	15	11	11	9.4	7.9	6.9
12	8	10	18	16	12	12	8.9	7.4	8.2	5.4	5.5
32	21	23	16	16	14	9.0	3.4	1.9	1.0	0.4	0.5
187	203	163	140	110	88	57	29	22	14	10	11
337	284	272	251	239	202	125	76	68	59	47	48
1.8	1.2	1.1	0.9	0.9	0.7	0.4	0.4	0.4	0.2	0.2	-[h]
167	168	163	133	118	127	76	63	54	40	33	31
130	122	98	87	118	105	61	50	27	6.4	1.4	1.6
15	6.4	6.5	6.5	5.8	8.2	7.2	6.7	7.6	7.3	6.8	7.1
538	545	497	369	375	336	261	151	146	115	125	98
480	290	223	310	48	51	53	26	20	12	-[h]	-[h]
1,252	785	628	1,209	46	37	5	-[h]	-[h]	-[h]	-[h]	-[h]

[e]Hyperion 7-mile outfall not included.

[f]Only Hyperion data were available.

[g]Estimates for 1971 through 1975 were based on SCCWRP analyses of effluents; estimates for 1976 through 1989 were based on discharger data.

[h]Concentrations were below detection limits.

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).

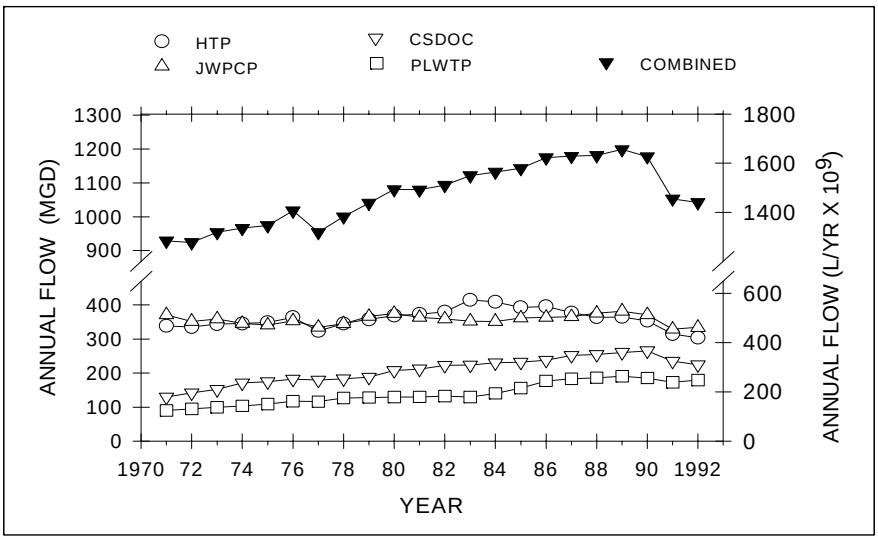
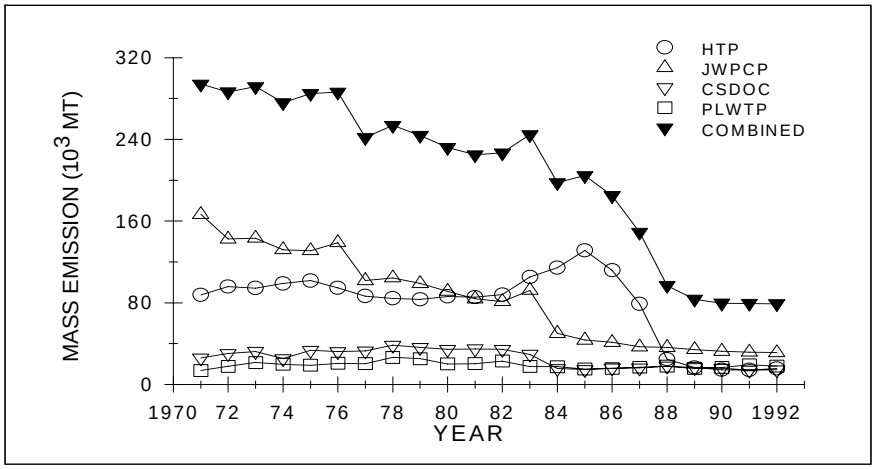


Figure 3.

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



City of Los Angeles have expanded their upstream treatment and reclamation facilities. The JWPCP reclaimed 131 mgd of water in 1992 —nearly 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 72 mgd in 1992 (City of Los Angeles 1992a,b).

Despite increases in population and the volume of wastewater discharged during the past two decades, the mass emissions of most effluent constituents have declined (Table 4). The combined mass emissions have decreased for suspended solids (73%), BOD (52%), and oil and grease (69%) (Figures 3, 4, and 5). The decline in JWPCP solids emissions between 1971 and 1989 accounted for 65% of the reduction. 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. Most of the decline in BOD occurred after 1985. Reductions by JWPCP accounted for about 75% of the decline in oil and grease.

The combined mass emission of trace metals declined 94% from 1971 to 1992 (Table 4; Figure 6). Declines of individual metals averaged 83% (sd=23%, n=8, arsenic and mercury excluded). Arsenic was reported only by HTP in 1971. Mercury declined from 2.9 mt to non-detectable levels. The greatest reductions were for cadmium (99%), lead (99%), chromium (98%), zinc (95%), copper (91%), and nickel (90%). From 1972 to 1992, arsenic declined 69%. The combined mass emissions of trace metals declined 36% from 1987 to 1988; 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 95%.

The combined emissions of chlorinated hydrocarbons declined more than 99% from 1971 to 1992 (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 Los Angeles County sewer system from 1947 to 1971. Residual waste in the sanitation system was the principal source of DDT in JWPCP effluent after that time. Concentrations of DDT in JWPCP effluent are now below detection limits.

The interpretation of long-term trends is hindered somewhat by the questionable reliability of trace contaminant analyses (particularly organic) in early 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 are 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.

Conclusions

The quality of municipal wastewaters discharged to the Southern California Bight has significantly improved 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 major municipal wastewater treatment facilities are not likely to be so 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.

Figure 4.

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

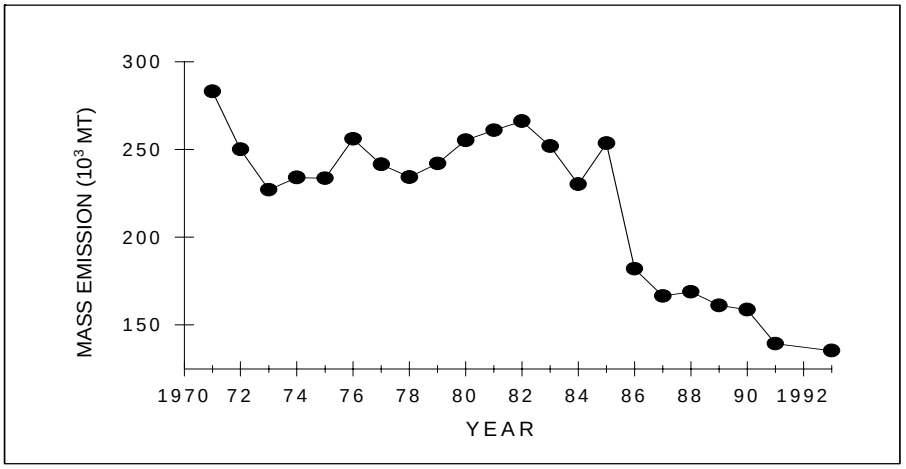


Figure 5.

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

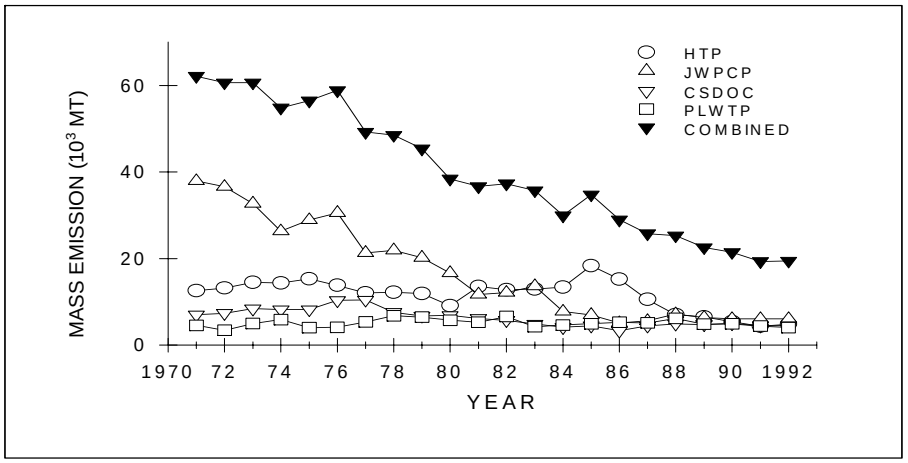


Figure 6.

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

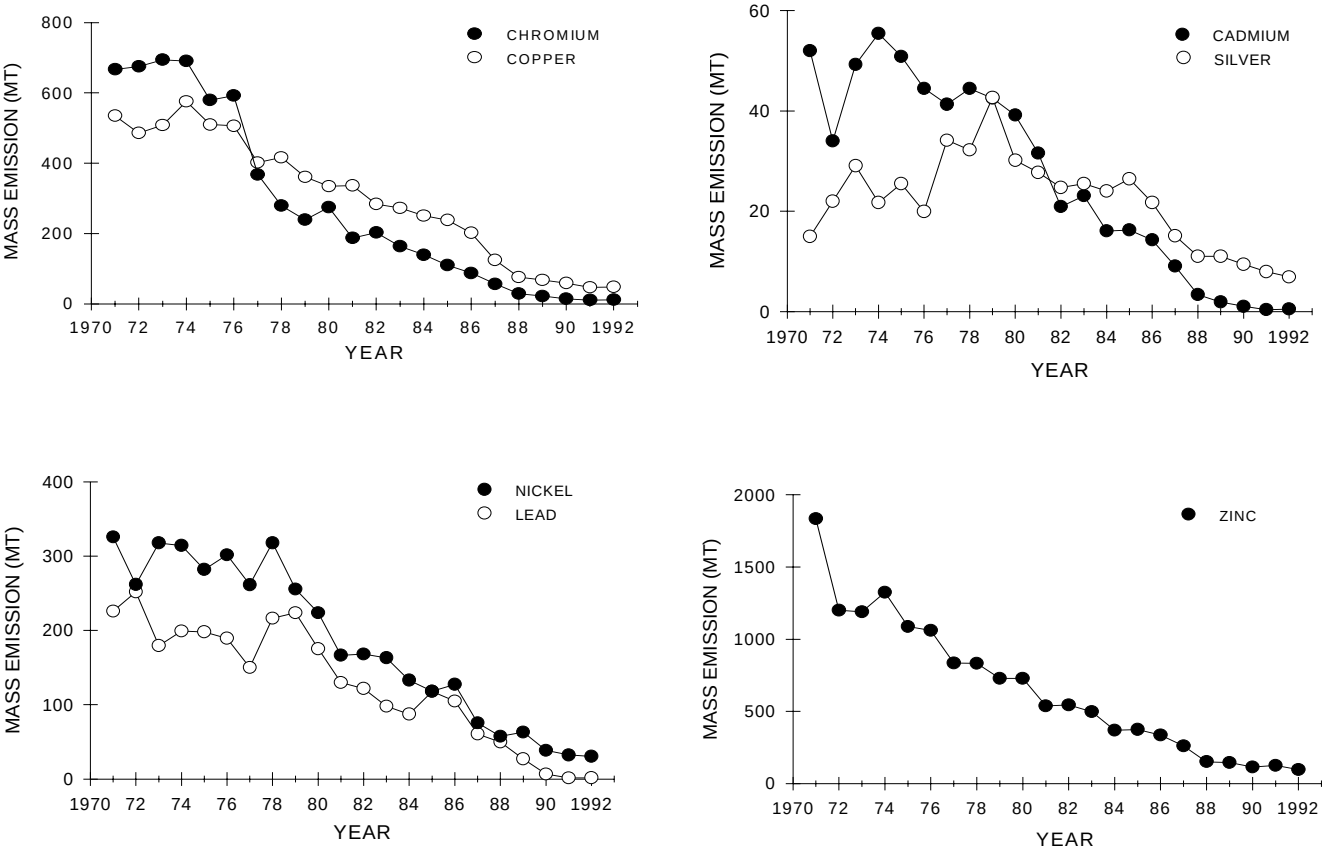


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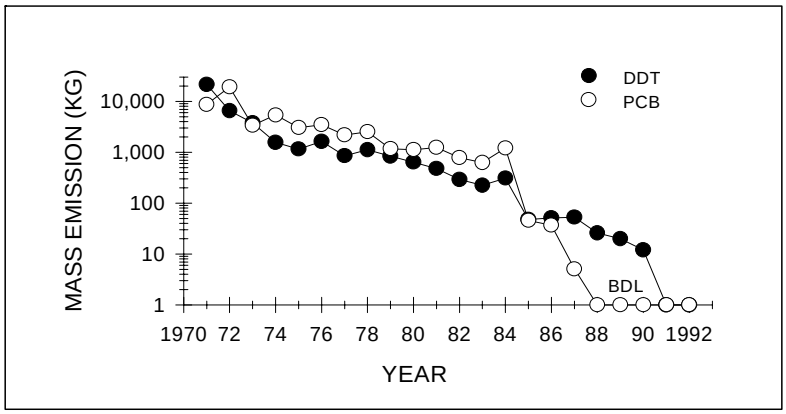
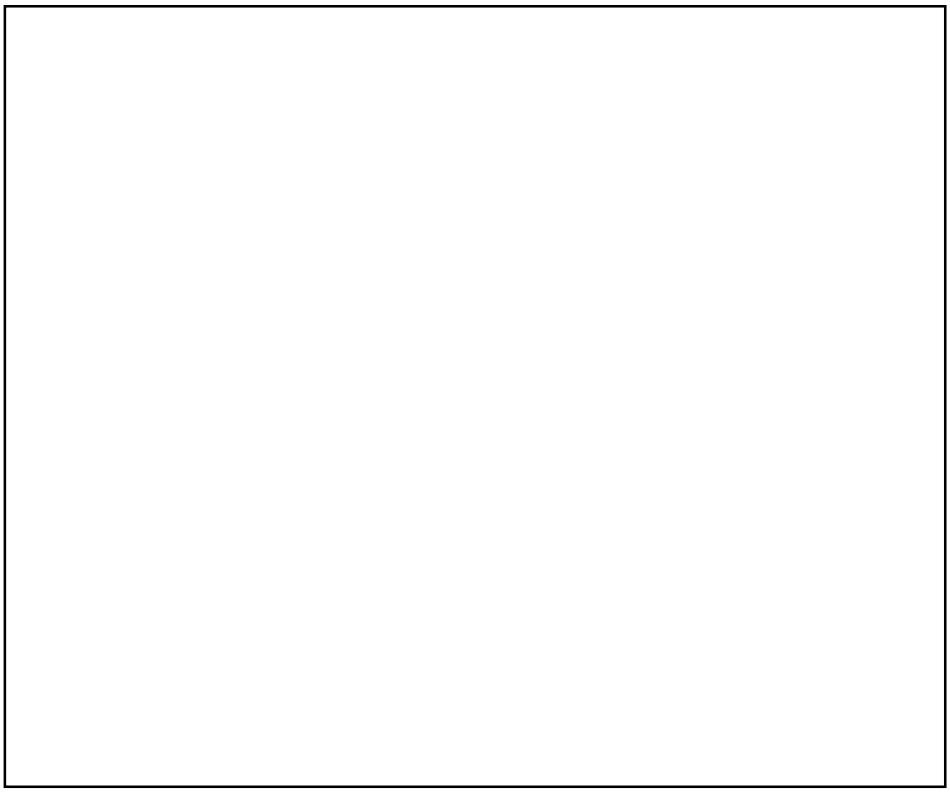
Figure 7.

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





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Acknowledgements

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Appendix 1.

Mass Emission Equation

Annual mass emissions (ME) of constituents 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 in 1992 (SCCWRP 1992), differs from previous SCCWRP reports where we estimated mass emissions by the product of total annual flow and mean annual constituent concentration (e.g., SCCWRP 1990). Constituent concentrations below detection limits were treated as zeros in both estimation methods. If annual means were below detection limits, they were reported as detection limits in the table of concentrations (Table 2) and the mass emissions were set to missing. Estimates by the two methods differ by <1%; therefore, the historic mass emission data have not been recalculated.