SEDIMENT TRAP APPLICATIONS IN THE NEARSHORE REGION *

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ABSTRACT

The impact of a major sewage sludge discharge to Santa Monica Submarine Canyon off the Southern California coast has been studied using sediment traps to collect settling particulate matter in the vicinity of the discharge. The samples collected by the sediment traps revealed that both the fallout rates and the organic content of settling particulates are greatly influenced by the sludge discharge, but only in the immediate vicinity of the outfall. The particulate fallout rates and organic content were found to approach natural levels rapidly within a few kilometers of the discharge point. The discharged sludge was found to contribute less than 20% of the total particulate fallout and about 40% of the organic fallout to the Santa Monica Canyon ocean bottom.

INTRODUCTION

Coastal population centers have traditionally used the ocean as a disposal site for treated municipal wastewaters and, in some cases, for treatment plant sludges as well. The wastewaters and sludges contain a complex mixture of organic and inorganic substances in both dissolved and particulate phases. In general, a major portion of the wastewater constituents considered to be potential pollutants (heavy metals, chlorinated hydrocarbons, and oil and grease) are associated with the particular matter in the discharges. Consequently, a knowledge of the relatively immediate physical fate of the waste particulates is essential to an evaluation of the effects of wastewater discharges to the ocean. The use of sediment traps to collect samples of the settling particulate matter in the vicinity of wastewater outfalls is one method currently being used to gain such knowledge.

SAMPLING AND ANALYTICAL PROCEDURES

The sediment trap being used at the Coastal Water Research Project was designed by Andrew Soutar of Scripps Institute of Oceanography and consists of an inverted cone with a $0.05m^2$ collecting surface at the top and a removable sample container at the bottom. The entire device is supported on a tripod frame which holds the collecting surface approximately 2m above the ocean bottom. In 1974, four sediment traps were used to collect 29 samples at 22 stations over a period of about 7 months. The sampling period at each station ranged from 14 to 39 days and averaged 24 days.

The samples were refrigerated once on board ship and frozen upon arrival at the Project's laboratory the same day (samples that were to be analyzed the next day were kept refrigerated overnight). We determined the total amount of particulate solids in the samples and the organic content of the solids, using procedures described below. In the future months, we also will analyze the collected solids for chemical oxygen demand, oil and grease, trace metals, and chlorinated hydrocarbons.

Total particulate solids procedure

The samples were first centrifuged to concentrate the solids. The centrate was decanted and the wet solids transferred to a tared drying dish and weighed. The solids were dried at 80°C for 24 hours and weighed again. The sea salt content of the dry solids was estimated from the moisture loss, and this amount was subtracted from the weight of the dried solids (this correction ranged from negligible to 22%, depending upon the characteristics of the solids).

Solids organic content procedure

A small subsample of the dried solids was redried and weighed. This sample was then ashed at 550°C for 1 hour, cooled in a dessicator, and reweighed. The value for the weight lost in ashing was adjusted for the weight lost from combustion of the volatile components of the sea salts present. The adjusted weight loss was considered to be due to the combustion and volatilization of the organic matter present in the sample and was used as a measure of the organic matter.

STUDY DESCRIPTION AND RESULTS

The region selected for this study was the Santa Monica Canyon in Santa Monica Bay, California. The City of Los Angeles Hyperion Sewage Treatment Plant discharges 5 million gallons per day of a mixture of treatment plant sludges and secondary effluent at the head end of the canyon. About 131 metric tons of dry particulate solids per day are discharged through this system, and the organic content of these solids is usually between 60 and 70%. The objectives of the Coastal Water Project's study were to determine: (1) the rates of fallout of the discharged particulates at selected stations in the canyon region, and (2) the physical and chemical properties of the settling particulates at each station (limited to data on organic content at this time).

* Contribution 34 of the Coastal Water Research Project.

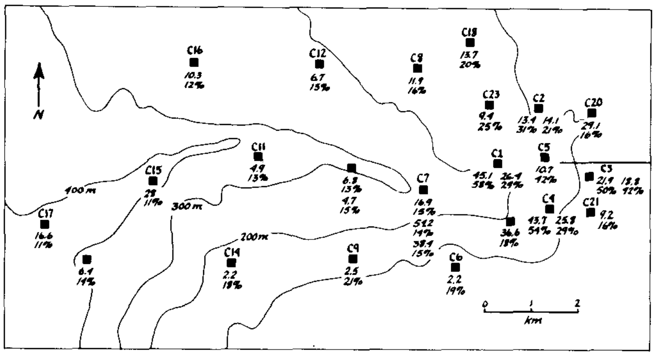

FIGURE 1. Santa Monica Canyon sediment trap stations, observed sedimentation rates (gm/m²/day), and organic content of trapped solids (%).

The calculated sedimentation rates ranged from 2.2 to 107 g dry solids m^2/day, with the higher values occurring near the discharge point (Figure 1, Table 1). We took more than one sample at several of the stations to get an idea of the sedimentation rate variation from one sampling period to another: Five stations, C1, C2, C3, C4, and C10, were sampled twice, and one station, C7, was sampled three times. The observed deviations ranged from 2.5 to 54% of the mean station values, with an average deviation from the mean of 18%. As the quality and characteristics of the particulate matter discharged are fairly constant, these variations are probably due to changes with time in the water movement patterns in the canyon area. Variations in currents in the study area could change the speed and direction of discharged particulate transport and the quantity of resuspended surface sediments collected at any sediment trap station.

Current measurements were made at only one station, C17. Bottom currents at that station were recorded every 15 minutes for a period of 3 weeks in September 1974. The predominant currents recorded were downcanyon, with a net speed of 5.5 cm/sec. The highest current speed recorded was 32 cm/sec, and all currents greater than 25 cm/sec were downcanyon.

To compare the sedimentation rates obtained with the amount of solids discharged on the basis of mass per unit time, we assigned areas to each of the stations and estimated the total mass flux over the study area (69 km^2). The estimated total solids fallout of 825 metric tons per day was 6.3 times the particulate solids discharge rate of 131 metric tons per day. The estimated organic solids fallout of 203 metric tons per day was 2.4 times the discharge rate of 85 metric tons per day.

The fact that there appeared to be much more particulate matter falling to the bottom of the canyon than was discharged at the head end may be the result of many factors. The sedimentation of marine particulate matter naturally occurring in the study area certainly accounted for some of the excess. No data have been found in the literature regarding sediment accumulation rates in submarine canyons. Emery (1960) studied sediment accumulation rates at several locations off the southern California coast and reported a net sediment accumulation rate of 3.4 $g/m^2/day$ for a station in Santa Monica Basin, his sampling station closest to the Santa Monica Canyon. This number corresponds closely with the sedimentation rates measured in this study at stations distant from the outfall. Andrew Soutar (Scripps Institution of Oceanography, pers. comm.) has measured the fallout rates of particulate matter in eight basins off southern California, using sediment traps similar to those used in this study. The rates he recorded range from 0.23 to 2.44 $g/m^2/day$, with an average of 0.74 $g/m^2/day$. His value for Santa Monica Basin is 0.69 $g/m^2/day$, a factor of five lower than Emery's estimate.

It must be noted that the sediment traps collect falling matter. Thus, we are measuring particulate matter fallout rates, which may be quite different than sediment accumulation rates. Transport mechanisms such as bottom scour, which resuspends sediment and may greatly affect the sediment accumulation rate, are not operative within the sediment traps. The collection of resuspended sediments by the sediment traps is an unknown that could be significant. The speed of the canyon currents that we measured (9% of the observations

TABLE 1

Sediment Trap Data Summary 1974

Station	Sampling period	Total Solids		Organic content (%)
		Sample size (g)	Fallout rate (g/sq m/day)	
C1	5 Jun to 19 Jun	31.6	45.1	26.4
	19 Jun to 23 Jul	98.0	57.6	28.9
C2	5 Jun to 19 Jun	9.4	13.4	30.7
	19 Jun to 23 Jul	23.9	14.1	20.6
C3	5 Jun to 19 Jun	15.3	21.9	49.7
	19 Jun to 23 Jul	32.0	18.8	41.5
C4	5 Jun to 19 Jun	30.6	43.7	53.5
	19 Jun to 23 Jul	44.0	25.9	29.0
C5	23 Jul to 7 Aug	80.0	107.0	42.3
C6	15 Aug to 29 Aug	1.5	2.2	18.5
C7	4 Oct to 25 Oct	17.7	16.9	15.3
	25 Oct to 19 Nov	67.7	54.2	13.5
	19 Nov to 12 Dec	44.2	38.4	15.1
C8	23 Jul to 29 Aug	22.0	11.9	16.2
C9	29 Aug to 12 Sep	1.7	2.5	20.7
C10	4 Oct to 25 Oct	7.1	6.8	12.7
	25 Oct to 19 Nov	5.8	4.7	14.6
C11	29 Aug to 4 Oct	8.9	4.9	12.8
C12	29 Aug to 12 Sep	4.7	6.7	15.2
C13	29 Aug to 12 Sep	4.5	6.4	13.8
C14	12 Sep to 4 Oct	2.4	2.2	18.4
C15	4 Oct to 25 Oct	29.4	28.0	11.0
C16	12 Sep to 4 Oct	11.3	10.3	12.3
C17	12 Sep to 4 Oct	18.2	16.6	11.2
C18	4 Oct to 25 Oct	14.4	13.7	20.0
C19	12 Dec to 3 Jan	40.3	36.6	17.9
C20	12 Dec to 3 Jan	32.0	29.1	16.3
C21	25 Oct to 3 Jan	17.9	9.2	16.2
C23	19 Nov to 12 Dec	10.8	9.4	24.9

were greater than 20 cm/sec) are sufficient to cause scour and resuspension of unconsolidated sediments (Hjulstrom 1939; Southard, Young, and Hollister, 1971). In the future, we plan to compare the sedimentation rates with estimated sediment accumulation rates since 1960, when the waste discharge began, to get an estimate of the importance of scour and resuspension as a transport mechanism in the study area.

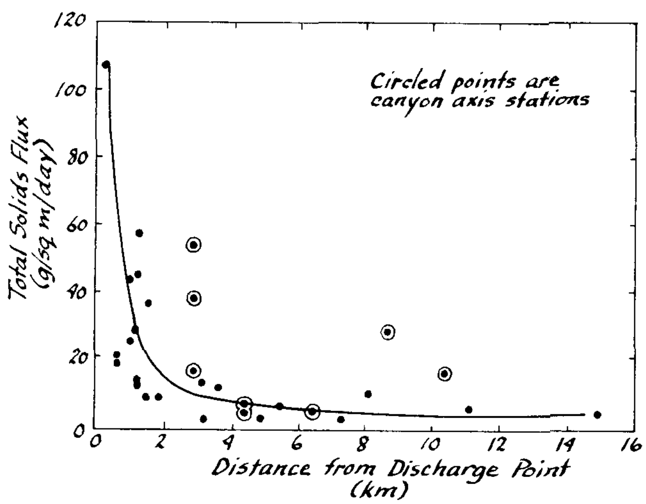

FIGURE 2. Observed sedimentation rates vs. location.

Most of the waste particulates discharged at the head of Santa Monica Canyon fall to the bottom within a few kilometers of the discharge point (Figure 2). A line indicating the trend of the data has been fitted by eye. The data are scattered about this proposed trend for a number of reasons, and some of this scatter appears not to be random. Beyond 2 km from the discharge point, the four obviously high data points are from canyon axis stations (C7, C15, and C17), and the three lowest points represent the three stations along the southern lip of the canyon (C6, C9, and C14). The influence of the outfall discharge on the flux of particulates to the bottom appeared to be greatest at or near the point of discharge and decreased rapidly within a distance of 2 to 3 km. Assuming a net current downcanyon of 5 cm/sec, this distance represents approximately 11 to 17 hours residence time in the water column for the settling wastewater particulates.

The organic content of the trapped solids decreases rapidly with distance from the discharge point (Figure 3). A line indicating the trend of the data has been fitted by eye. The shape of this curve is remarkably similar to that in Figure 2. The major influence of the discharged waste particulates, which average about 65% volatile solids, in determining the character of the particulate fallout was limited to an area within about 2 km of the discharge. If the effects of the waste particulates approach zero with increasing distance from the outfall, then the organic content of the collected particulates should approach that of natural marine fallout. We can estimate the probable range for the organic content of natural fallout to be 10 to 15% (Figure 3). Two samples collected with sediment traps placed in Catalina Canyon were analyzed for organic content according to the procedures already described. The values for the these were 11% and 12%, numbers which fit well with the hypothesis that most of the particulate matter collected by the sediment traps more than 2 km from the outfall is natural to the study area. Additional analyses of the chemical characteristics of the samples will be helpful in evaluating this interpretation of the data.

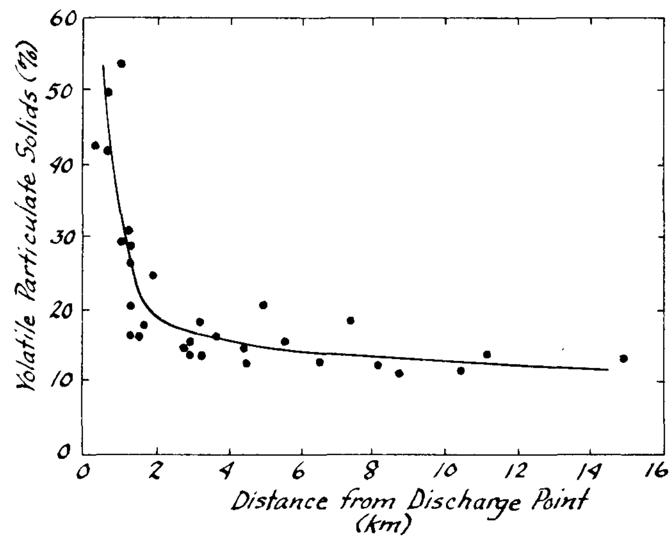

FIGURE 3. Organic content of settling particulates vs. location.

CONCLUSIONS

Although much of the data from this study are not yet available, the following preliminary conclusions have be made, based upon data presented in this paper.

1. Sediment traps are useful devices for the collection of settling particulate matter in the ocean.
2. Most of the waste particulates discharged at the head of Santa Monica Canyon fall to the bottom within a distance of 2 km of the point of discharge.
3. Natural fallout in the Santa Monica Canyon is in the range of 2 to 20 $g/m^2/day$, with an organic content of 10 to 15%. High deposition rates occur aperiodically, primarily along the canyon axis; these probably result from resuspension and transport of the sediment by strong bottom currents.

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