Time Series of Trace Element Concentrations Calculated from Time Series of Suspended Solids Concentrations and RMP Water Samples: Summary and Conclusions[1]

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Introduction

The supply and fate of trace elements in San Francisco Bay, which are partially dependent upon particulate matter in the Estuary, are important management issues. San Francisco Bay receives many waste water discharges, especially in areas south of the Dumbarton Bridge, that contain trace elements that accumulate in benthic organisms (Luoma *et al.*, 1985; Brown and Luoma, 1995). Trace elements tend to adsorb particulate matter (Kuwabara *et al.*, 1989), so the fate of trace elements is partly determined by the fate of suspended solids. Concentrations of dissolved trace elements are greater in the South Bay than elsewhere in San Francisco Bay, and bottom sediments are believed to be a significant source (Flegal *et al.*, 1991). The concentration of suspended particulate chromium in the Bay appears to be controlled primarily by sediment re-suspension (Abu-Saba and Flegal, 1995). Water quality standards for trace elements in the Bay are written in terms of total or near-total trace element concentrations (TEC).

This summary has two objectives. The first is to demonstrate the relationship between suspended solids concentration (SSC) and TEC by developing equations relating SSC to total (or near-total) concentrations of trace elements based on Regional Monitoring Program (RMP) data collected during 1993 and 1994. The second objective is to demonstrate the temporal variability of TEC that are linearly correlated (LCTEC) with SSC by presenting time-series information on LCTEC based on nearly continuous SSC measurements collected during the 1995 water year (October 1, 1994 to September 30, 1995) and the SSC-LCTEC equations.

Data Collection

During 1993 and 1994, the RMP conducted six sampling trips in San Francisco Bay during which water quality samples were collected and analyzed for many constituents, including SSC and TEC (SFEI, 1994; SFEI, 1996). The USGS has also established several SSC monitoring sites in San Francisco Bay at which SSC is measured every fifteen minutes. (Buchanan and Schoellhamer, 1995; Buchanan *et al.*, 1996).

Relations Between RMP SSC and TEC Data

Linear regression was used to determine equations relating RMP SSC and TEC data. The equations were applied to the USGS SSC measurements in Bay waters, so outlying data collected in tributary streams were discarded.

Excellent correlations with SSC were found for seven trace elements—silver, chromium, copper, mercury, nickel, lead, and zinc. For example, the linear regression for mercury is shown in Figure 48 (115 samples, r^2 is 0.90). All regressions are significant at less than the 0.001 level. SSC accounts for approximately 90 percent of the variability in the LCTEC. Poor correlations with SSC were found for the other three trace elements measured by the RMP—arsenic, cadmium, and selenium.

Outlying data from tributaries had either low or high LCTEC compared to the predicted values based on SSC ('x' symbols in Figure 48). These data probably reflect the influent waters, not Bay waters, and therefore were discarded. For example, influent from waste water treatment plants sometimes had a greater ratio of LCTEC to SSC than Bay

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[1] This summary contains excerpts from a more extensive report available from SFEI.

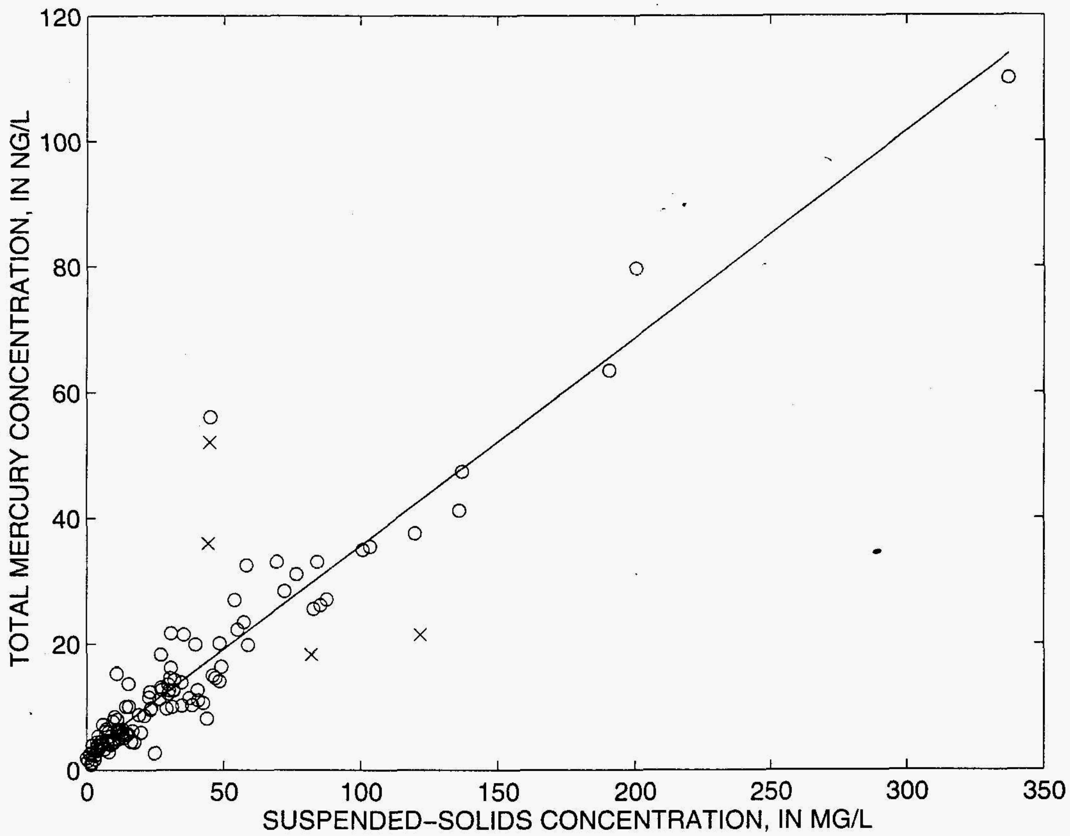

Figure 48. Correlation of SSC and total or near-total concentrations of mercury. Outliers from samples taken from influent waters are indicated with an 'X'

waters, and influent from natural rivers sometimes had a smaller ratio of LCTEC to SSC than Bay waters. Not all data collected at the tributary sites are outliers because Bay waters may be present at the sites (during flood tides for example), the tributary discharge may be small, or the ratio of LCTEC to SSC of the influent water may be close to that of Bay waters.

USGS SSC Data

An example time series of measured SSC data from mid-depth at Point San Pablo is shown in Figure 49. The high frequency variations were caused by tidal advection and tidal re-suspension of suspended solids. The fortnightly variation was caused by the spring-neap cycle. About one-half the variance of SSC was caused by the spring-neap cycle, and SSC lags the spring-neap cycle by about 2 days (Schoellhamer, 1996). The relatively short duration of slack water limited the duration of deposition of suspended solids and consolidation of newly deposited bed sediment during the tidal cycle, so suspended solids accumulated in the water column as a spring tide was approached and slowly deposit as a neap tide was approached. High concentrations in January and March were the result of runoff from the Central Valley, which transported suspended sediments to the Bay. Stronger winds during spring and summer increased sediment re-suspension in shallow water and thus increased SSC throughout the Bay.

Calculated LCTEC During Water Year 1995

LCTEC and SSC vary similarly in time because they are linearly related. An example calculated LCTEC time series for mercury at mid-depth at Point San Pablo is shown in Figure 49. Total mercury concentration varied because of tidal advection and tidal re-suspension of suspended solids and associated mercury, the fortnightly spring-neap cycle, and the seasonally stronger summer winds. The high inflow during January and March increased SSC and, assuming that the relationship between SSC and total

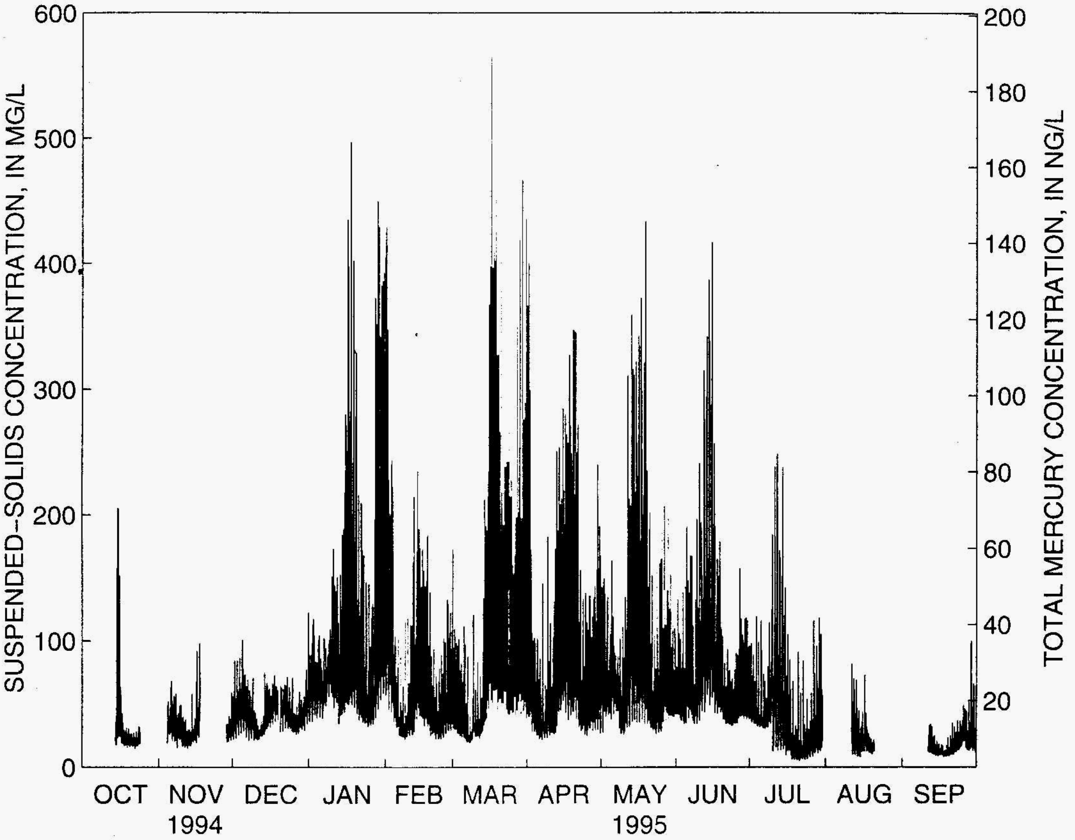

Figure 49. Time series of mid-depth SSC (measured) and total mercury concentration (calculated) at Point San Pablo, water year 1995.

mercury concentration was unchanged at Point San Pablo, increased total mercury concentration. RMP data collected in February and April of 1995 in the Northern Estuary (SFEI, 1995) indicates that the relationship was virtually unchanged in the open Bay waters. As with SSC, about one-half the variance of LCTEC was caused by the spring-neap cycle.

Discussion and Conclusions

Seven TEC are well correlated with SSC for Bay waters. Influent waters from waste water treatment plants sometimes had a greater TEC to SSC ratio than Bay waters, and natural tributaries sometimes had a smaller ratio than Bay waters. Linear equations relating LCTEC and SSC can be applied to the nearly continuous time series of SSC collected by the USGS to produce similar time series of LCTEC.

Because of their relationship with SSC, LCTEC vary with time because of tides, the spring-neap cycle, seasonal winds, and watershed runoff. Frequent sampling, on the order of minutes, is required to observe these variations, but such a TEC sampling program would be prohibitively expensive. The combination of the existing RMP sampling data and USGS SSC data produces computed LCTEC every 15 minutes at the USGS SSC monitoring sites. These computed LCTEC can be used to monitor temporal variations in LCTEC that the RMP sampling program can not observe and thus enhance the existing direct RMP TEC measurements by helping to place them in a proper context.

Acknowledgments

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