GREEN INFILL FOR CLEAN STORMWATER

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ABSTRACT

Detrimental impacts of stormwater runoff from transportation infrastructure have been well documented. The Green Infill for Clean Stormwater Project promotes sustainable green streets and parking lots by developing approaches to reduce impacts of water pollution from road runoff. The reductions will be achieved through the construction of rain gardens, bio-swales, infiltration- and flow-through planters, curbside extensions, or a combination of these techniques and monitoring to evaluate their effectiveness. A first set of samples was collected during storms in the winter and spring of 2009 from a parking lot/recreational complex prior to the implementation of best management practices. Concentrations of trace metals were high during the pre-construction sampling, from 5 (HgT) to 15 (Hg diss) times higher in runoff from the parking lot compared to the 14-year Central Bay average from the Regional Monitoring Program for Water Quality in the San Francisco Estuary (RMP). Concentrations for cadmium, copper, nickel, lead, and zinc were also high, between 7 (Ni) and 296 (Zn) times higher than found in the Bay. PCB concentrations were twice as high in the stormwater runoff compared to Bay averages, while PAH concentrations in the runoff were 88 times higher than the observed long-term average concentrations in San Francisco Bay. The toxic gasoline additives benzene, toluene, and xylene or BTX were not detected in any of the collected samples.

STUDY DESIGN

Water samples were collected during rainfall events from a pipe draining a parking lot/recreation complex in Daly City, CA (**Figure 1**). Runoff water from this site drains directly into San Francisco Bay via the city storm drain infrastructure. In the spring of 2009 a total of six samples were collected during three storms. Depending on the intensity of the rain and the response time of the system, samples were collected during different stages of the hydrograph (**Table 1**). All sampled storms (3/22, 4/7, 5/1) were approximately two to three weeks apart without any runoff washing off the parking lot in between these dates.

Figure 1. Daly City parking lot. Drainage area is approximately 4 acres with a 0.35 mi perimeter (0.02 km² with 0.56 km perimeter).

Table 1. Sampling events in the spring of 2009.

Dates	Rainfall (inches)	Sampling Events	Stage	SSC (mg/L)
3-Mar-09	0.08	Pre-project	-	-
22-Mar-09	0.10	1	peak	14
22-Mar-09	0.01	2	falling	2.9
7-Apr-09	0.03	3	rising	42
7-Apr-09	0.08	4	peak	26
1-May-09	0.16	5	peak	26
1-May-09	0.04	6	falling	16

RESULTS

Concentrations of metals and organic contaminants during the pre-construction sampling period were relatively high and several times above long-term averages that are reported for San Francisco Bay. Mercury (Hg) is a major problem in San Francisco Bay because it accumulates to high concentrations in fish and wildlife species. Hg concentrations measured in this study were 5 (HgT) to 15 times (Hg diss) higher compared to the San Francisco Bay average (**Table 2**).

Other trace metals that were measured in this study, with sources that may include building siding and roofs, automobile brakes, tires, also showed very high concentrations in the pre-construction parking lot runoff. Concentrations were 7 (nickel) to 296 (zinc) times greater than the reported Bay average (**Table 3**).

The highest PCB (polychlorinated biphenyls) and PAH (polycyclic aromatic hydrocarbons) concentrations were observed during the rising stage of the hydrograph at 1,315 and 4,555,000 pg/L, respectively (**Figure 3**). PCB contamination remains one of the greatest water quality concerns in San Francisco Bay and the measured average concentration in the parking lot runoff was twice as high as the long-term RMP average (**Table 4**). PAHs are included on the 303(d) List for several locations in San Francisco Bay and concentrations in Central Bay, the segment of the Bay that Daly City water drains into, have been the highest in sediments along the western shoreline for almost a decade. Average PAH concentrations in the parking lot runoff were 88 times higher than the average measured in the Bay. Octa-chlorinated dioxin (OCDD) is representative for the presence of dioxins in the runoff water although the toxic tetra dioxins were not detected. Only the April rising stage sample had a detected concentration of total tetra-furans with 0.56 pg/L. Data for concentrations of dioxins and furans in Bay waters are not available for comparison. The second March sample had the lowest concentrations for trace metals and trace organics, largely due to the lowest suspended sediment concentration (SSC) that was measured in this study (3 mg/L; average = 21 mg/L) (**Table 1**).

Figure 2. Concentrations of methylmercury, total mercury, and dissolved mercury measured in six runoff samples collected in the spring of 2009

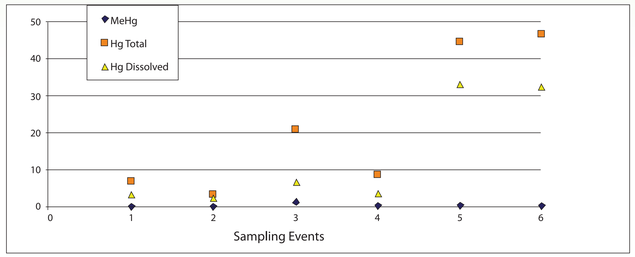

Figure 3. Concentrations of octa-chlorinated dioxin, polychlorinated biphenyls, and polycyclic aromatic hydrocarbons measured in six runoff samples collected in the spring of 2009.

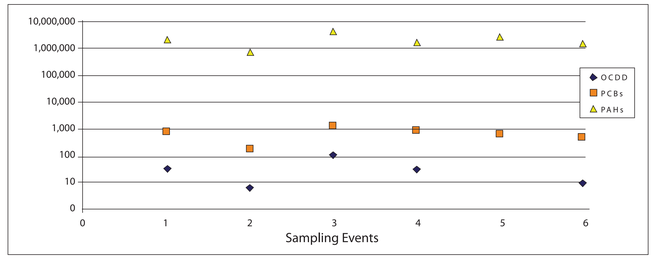

Table 2. Methylmercury, total mercury, and dissolved mercury concentrations of the present study compared to the 14-year Central Bay average from the Regional Monitoring Program for Water Quality in the San Francisco Estuary.

Sample Number	MeHg (ng/L)	HgT (ng/L)	Hg diss (ng/L)
1	0.34	6.9	3.7
2	0.19	3.5	2.4
3	1.54	21.0	6.8
4	0.51	8.7	3.9
5	0.73	44.7	33.4
6	0.47	46.9	32.6
Average	0.63	21.9	13.8
RMP 14-year average for Central Bay	0.06	4.6	0.9
Degree of elevation relative to the Bay	11	5	15

Table 3. Cadmium, copper, lead, nickel, and zinc concentrations of the present study compared to the 14-year Central Bay average from the Regional Monitoring Program for Water Quality in the San Francisco Estuary.

Sample Number	Cd (ug/L)	Cu (ug/L)	Pb (ug/L)	Ni (ug/L)	Zn (ug/L)
1	NA	21	1.6	6.3	297
2	NA	3	0.2	0.7	36
3	1.560	143	14.0	49.4	2490
4	0.203	34	2.1	9.7	359
5	0.343	50	2.4	18.0	678
6	0.125	25	1.1	7.5	271
Average	0.558	46	3.5	15.3	689
RMP 14-year average for Central Bay	0.070	2	0.4	2.3	2
Degree of elevation relative to the Bay	8	25	10	7	296

Table 4. PCB and PAH concentrations of the present study compared to the 14-year Central Bay average from the Regional Monitoring Program for Water Quality in the San Francisco Estuary.

Sample Number	PCBs (pg/L)	PAHs (pg/L)
1	815	2,291,000
2	182	669,000
3	1,315	4,555,000
4	910	1,843,000
5	691	2,729,000
6	483	1,645,000
Average	733	2,289,000
RMP 14-year average for Central Bay	400	26,000
Degree of elevation relative to the Bay	2	88

CONCLUSION

Pre-construction sampling has been completed as a first sep towards testing the effectiveness of a new parking lot BMP installation in Gellert Park, Daly City. Runoff treatment through rain gardens and bio-swales at this site is expected to decrease the amount of contaminants entering the Bay from this site since the trapping of particles in the soil will reduce the concentrations in water reaching the drain. This seems to be especially true for organic contaminants because they showed a strong relationship with SSC in the runoff. Additional treatment is also anticipated through the processes of infiltration, sorption, and biofiltration, processes that are effective for trapping or transforming substances transported in dissolved forms. Further sampling will be conducted this winter after construction is completed and results for contaminants concentrations and flows will be used to calculate and evaluate potential load reductions.