SOIL HYDROCARBON CONCENTRATIONS IN THE SOUTH FIRST STREET STORM WATER RUNOFF BASIN, POCATELLO, IDAHO

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ABSTRACT

The First Street Stormwater Retention Basin (FSSRB) was designed to collect urban storm water runoff from a portion of the City of Pocatello, ID Soil Total Extractable Hydrocarbon (TEH) concentrations in the FSSRB were significantly higher at 0–5 cm depths (average = 688.5 ppm; range from 142 – 1340 ppm) than at 5–10 cm depths (average = 415.3 ppm; range from 44 - 1340 ppm), and there were significant differences in TEH concentration at different locations within the basin. The Idaho Department of Environmental Quality has not established regulatory limits for TEH that mandate further sampling, however ten states west of the Mississippi River have established action levels, or lower ranges for action levels, that vary from 40 – 100 ppm.

Key Words: soil, petroleum, hydrocarbon, urban runoff

INTRODUCTION

Contaminated storm water runoff is a major cause of non-point source (NPS) pollution, and it represents a significant cause of degradation in receiving waters (Tsihrintzis and Hamid 1997). Various authors have reported that urban storm water runoff is among the top four causes of water quality impairment of rivers in the United States (Novotny 1991; Novotny and Olem 1994, Walker et al. 1999).

Urban runoff can contain a variety of pollutants such as sediments, metals, salts, fertilizers, pesticides, and hydrocarbons (Paul and Meyer 2001). Hydrocarbons are a particular problem in urban settings; Stenstrom et al. (1984) found that parking lots had oil and grease loading factors of 239 kg/km^2 per cm of rainfall, more than 23 times the loading factor for residential areas.

Analysis of Total Extractable Hydrocarbons (TEH) has been used as an initial method to screen for the presence of hydrocarbons in soil or water. Although this type of analysis does not quantify concentrations of specific hydrocarbons, it does provide a measure of overall hydrocarbon contamination and is used in some states to determine if additional testing is warranted.

The goal of this study was to determine the general level of hydrocarbon contamination in the First Street Stormwater Retention Basin (FSSRB). We collected soils at two depths from 8 locations within the FSSRB and had samples analyzed for TEH. Although we do not have any data on soil hydrocarbon content when the basin was built, our data provide a current picture of hydrocarbon content and should serve as a useful point of comparison for future sampling

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METHODS AND MATERIALS

The First Street Storm water Retention Basin (FSSRB) was built to reduce non-point source inputs associated with storm water runoff into the Portneuf River. Completed in 1998, the roughly 0.8 ha FSSRB is located at the intersection of South First and Sutter Streets (Figure 1). When it was built the FSSRB received storm water runoff from about 895 ha within the City of Pocatello. Subsequent changes to storm sewers, completed in 2003, reduced that area to about 300 ha

The roughly 50 m wide basin is divided into four cells by three earth berms. Cell A is the narrowest of the four cells at about 23 m, cells B, C, and D are each about 32 m wide. Most water enters the basin at the northwest corner from a pipe that receives water from storm sewers: a smaller amount of water enters directly from South First Street down a concrete ramp into cell D. When the FSSRB was built the cells were all excavated to a level about 1.3 m below the grade of South First Street. There were slightly raised areas (spreading lips) of soil and gravel where adjacent cells met, designed to create a more even flow of water from one cell into the next. In 2003 cell A was excavated to a depth of about 1 m below the other cells to provide additional storage for sediments carried into the basin. As the water level in this cell rises water spreads to cell B and then to the other cells. The outlet drain is elevated above the bottom of cell D and permits surface flow out of the basin only when the water depth is greater than about 1.1 m.

Based on work in 1998, before the drainage area of the FSSRB was reduced, Whitmire (2000) estimated that precipitation events of 0.25 cm would result in measurable runoff into the basin, and 2 cm of precipitation would result in runoff volume of about 3,100 m^3, less than the 5,100 m^3 capacity of the FSSRB. Weather records from the Pocatello 2NE reporting station (the source of precipitation data used by Whitmire) indicate that from January 1992 through September 2004 there were 194 days on which there was at least 0.25 cm of precipitation, and 48 events when precipitation over a 48 hour period exceeded 2 cm. With the reduced drainage area, the intensity of rainfall events required to fill the FSSRB is now probably substantially larger than what was estimated by Whitmire. As a result, water from the majority of rainfall events large enough to produce flow into the FSSRB leaves the basin via evaporation or infiltration rather than direct flow into the Portneuf River.

The basin was planted during a two day period in July, 1998. Four plant species, *Carex nebrascensis* (Dewey) (Nebraska sedge), *Scirpus acutus* (Muhl) (hardstem bulrush), *Scirpus americanus* (Pers.) (3-square bulrush), and *Typha latifolia* (L.) (cattail), were planted in the basin to increase water retention time, increase evaporative losses via transpiration, and increase nutrient uptake. Cell A (closest to the inlet) was not planted because it was likely to require excavation to remove sediments, and cells B and D had both vegetated and unvegetated areas. The planted material successfully established in approximately half of cells B and C, and in approximately 75% of cell D. The remaining area was colonized by a variety of weedy plant species. Additional planting was done in 2000, when greenhouse-grown *Carex nebrascensis* and *Juncus balticus* (Willd.) (Baltic rush) were planted into areas of cells B and C where the original plantings had failed. At the time we sampled there were no large unvegetated areas in cells B, C, or D.

On 6 October 2004 we collected soil samples from the slightly elevated area

between cells A and B (Lip) and from two locations in each of cells B, C, and D (Figure 1). We did not sample cell A because it held standing water and we were primarily interested in testing for contamination of soil in the basin. Distances to the sample points were measured from the fence between the basin and South First Street. At the Lip, samples were taken at distances of 12 and 14 meters. In cells B, C, and D samples were taken at distances of 25 and 40 meters, roughly midway between the north and south sides of each cell. At each sample point a single 6.35 cm diameter core was pulled and divided into 0-5 and 5-10 cm depth increments. The soil corer was washed with Alconox and then rinsed with deionized water before taking each core to avoid contamination among samples. Soil samples were placed in separate glass jars with no remaining head space, placed in an ice chest, and sent the following day to Energy Laboratories, Inc. (Billings, MT) where they were analyzed for moisture content, for diesel range organics (DRO – all hydrocarbons between C10 and C28), and for total extractable hydrocarbons (TEH) (method SW8015M as D). The reporting limit (the minimum concentration that could be detected with 99% confidence) for samples ranged from 10 mg/kg, for samples with concentrations from 46 – 150 mg/kg, to 100 mg/kg, for samples with concentrations from 371 – 1340 mg/kg.

We analyzed soil moisture, TEH, and DRO using two-way Analysis of Variance (ANOVA), with location (Cell or Lip) and depth as independent factors. TEH and DRO data were log transformed to reduce heterogeneity of variances. Statistical analyses were performed with Systat version 10.0 for Windows (SPSS, Inc.).

RESULTS

There were two precipitation events during the two weeks before we collected soil samples, 0.84 cm on September 29 and 0.31 cm on September 30 (recorded at the Pocatello 2NE recording station). When we collected soil samples the only standing water in the FSSRB was in cell A, and the water surface was below the height of the soil between cells A and B (where the Lip samples were taken).

There were significant effects of location (Cell or Lip) ($F = 134.4$; $df = 3,8$; $P < 0.001$) and depth ($F = 17.5$; $df = 1,8$; $P = 0.003$) on soil moisture. Soil moisture was highest for samples collected at the Lip, and was higher for soils in the 0-5 depth interval than at 5-10 cm (Figure 2).

Total extractable hydrocarbon (TEH) concentrations ranged from 44 to 1340 mg/kg. Diesel range organics (DRO) concentrations ranged from 11 to 400 mg/kg, and averaged 25% of TEH across all samples. Figure 3 shows average TEH concentrations for samples from two depths at the Lip and in cells B, C, and D. For all samples the measured concentration of TEH was at least 3.7 (mean = 8 9) times the detection limit, regardless of any necessary dilution.

A two-way ANOVA using all of the data revealed significant effects of location (Lip or cell) ($F = 10.9$; $df = 3,8$; $P = 0.003$) and depth ($F = 11.5$; $df = 1,8$; $P = 0.010$) on TEH concentration. The mean TEH concentration for the top 5 cm was 688.5 ppm, while the mean concentration for the 5-10 cm depth was 415.3 ppm. The difference between the two depths was greater when the Lip samples were excluded (484 7 ppm for 0-5 cm, 113.7 ppm for 5-10 cm).

One of the two samples from cell D had a very high TEH concentration in the top 5 cm (1060 ppm, compared to an average of 369.6 for the other 0-5 cm samples in cells B, C, and D). The sample in cell D with the high TEH concentration was taken 25 m from the fence, closer to the concrete ramp than the 40 m sample.

Results for diesel range organics (DRO) were similar to those for TEH; there were significant effects of location ($F = 14.5$, $df = 3,8$, $P = 0.001$) and depth ($F = 12.1$, $df = 1,8$, $P = 0.008$) on DRO concentration.

DISCUSSION

The FSSRB appears to be reducing non-point source inputs associated with storm water runoff into the Portneuf River. Because only an unusually large runoff event will result in surface flow from the basin into the Portneuf River, virtually all sediment and contaminants in the runoff are retained in the basin.

The significant difference in TEH concentration between the two depth ranges is consistent with the hypothesis that hydrocarbons entered the FSSRB in storm water and were concentrated near the soil surface as water evaporated or percolated through the soil. Some of the differences in TEH concentration were consistent with the flow path of water through the FSSRB. We expect that the Lip between cells A and B is exposed to water, and in particular the surface of water where petroleum concentrations are likely to be highest, much longer than soils in cells B, C, and D, and the Lip is where we found the highest concentrations of TEH. This is consistent with the soil moisture data; soils collected at the Lip had significantly higher moisture content than soils in cells B, C, and D. The Lip was also the only location where the concentration of TEH at 5-10 cm was comparable to that at 0-5 cm. Average TEH concentrations declined from there through cell C, however the highest single value beyond the Lip was from cell D. This could have been the result of storm water flowing directly into the FSSRB down the concrete ramp on the east side of cell D.

We did not sample soils from cell A because there was standing water in that cell. Because that is the first cell to receive the majority of storm water runoff, and because water remains in that cell much longer than in the other cells, we predict that petroleum concentrations in cell A are higher than in the other cells. Based on the TEH concentrations at the Lip and in the other cells, sediments that are removed from the basin are likely to have concentrations of TEH that are high enough to warrant treatment or restricted disposal. The City of Pocatello does air farm sediments removed from the basin to reduce the concentration of hydrocarbons (Dan Sharp, Pocatello Environmental Engineer, personal communication).

Although there is an increasing emphasis on testing for specific chemicals or hydrocarbons where there is sufficient information about sources of contamination, the Idaho Department of Environmental Quality does use TEH concentrations as an initial means of evaluating an area for petroleum contamination in some areas (S. Owen, personal communication). If an initial evaluation reveals high TEH concentrations, further testing of individual constituents is implemented. Idaho has not established a specific TEH concentration that triggers additional sampling or soil cleanup, however a number of states have established TEH screening action levels in the 40 – 100 ppm range. Samples that exceed action levels trigger further screening that can include a fractionation step to measure concentrations of specific hydrocarbons. Given that only two soil samples had TEH concentrations that were below 50 ppm, and that the overall average concentration (551 9 ppm) was 5 – 10 times greater than many state action levels, we believe further sampling and analyses are warranted. In particular, we suggest that there be additional sampling to better characterize the depth profile of hydrocarbons, which could indicate the potential for groundwater contamination, and a regular sampling to detect future changes in soil hydrocarbon content.

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FIGURE LEGENDS

Figure 1. Map of a portion of Pocatello (left) and a schematic of the First Street Storm Water Retention Basin (right). The shaded areas on the map indicate the original area that drained into the basin (lighter shading) and the smaller area (darker shading) that drained into the basin after redirection of stormwater that resulted from work on the Halliday storm sewer line. The circle on the map indicates the location of the retention basin. Sample locations within the retention basin are marked with small circles.

Figure 2. Average soil moisture (% by weight) in the First Street Storm water Runoff Basin. Samples were collected from two locations between cells A and B (Lip), and from two locations in each of cells B, C, and D. At each location soil cores were divided into depth intervals of 0-5 and 5-10 cm. Circles represent soil moisture for individual samples, and horizontal lines represent mean values.

Figure 3. Total extractable hydrocarbon concentrations in the First Street Storm water Runoff Basin. Samples were collected from two locations between cells A and B (Lip), and from two locations in each of cells B, C, and D. At each location soil cores were divided into depth intervals of 0-5 and 5-10 cm. Circles represent TEH concentrations for individual samples, and horizontal lines represent mean values.

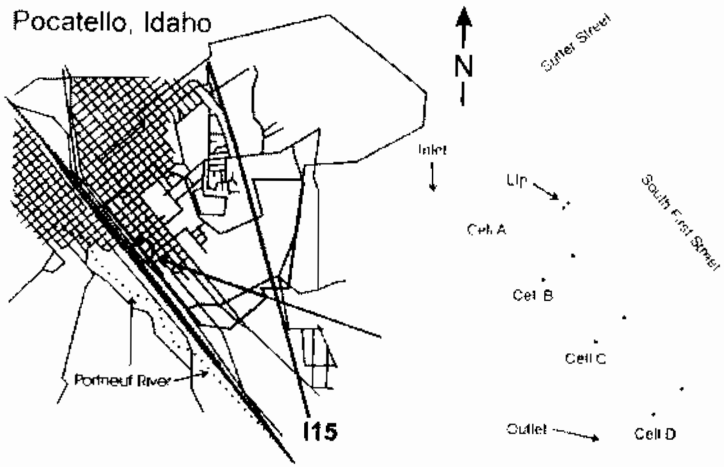
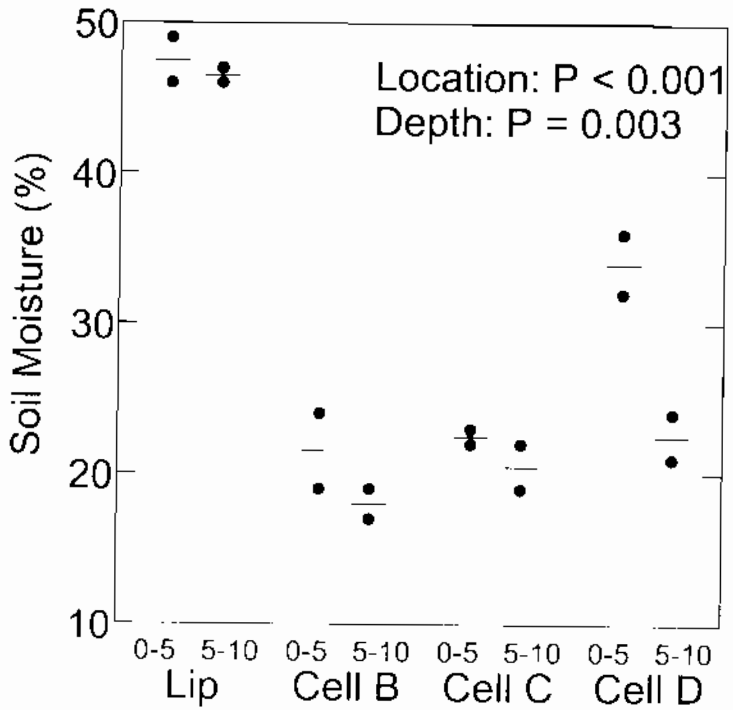


Figure 1



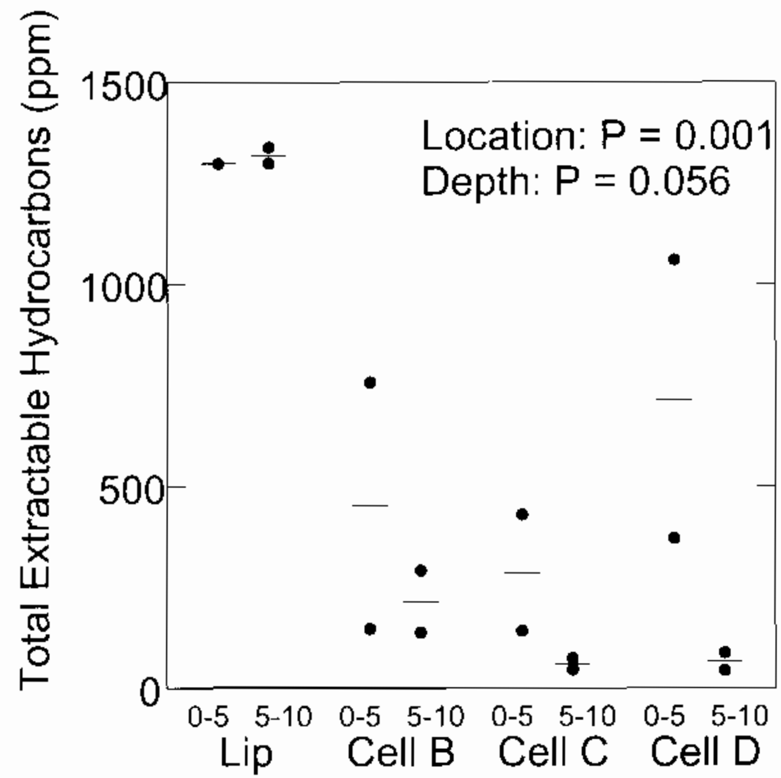


Figure 3