

---

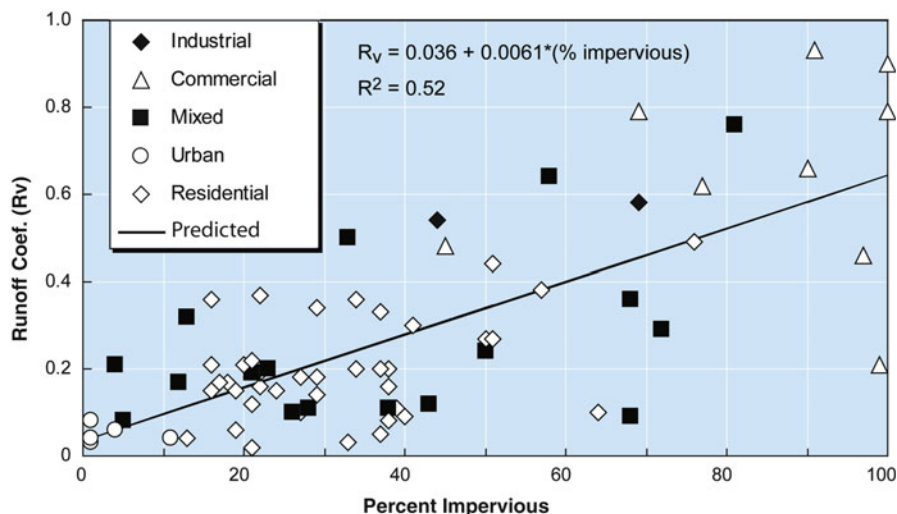
## Abstract

If construction or development occurs in a watershed, the area of impervious surfaces such as roads, parking lots, and buildings typically increases, with a corresponding decrease in the area of natural pervious surfaces. The result is an increase in stormwater runoff volumes, peak flow rates, and a degradation of runoff quality. The degradation of runoff quality can be observed in increased concentrations and total mass loads of nutrients and other organics, metals, chlorides, bacteria, viruses, hydrocarbons, and other substances, as well as increases in runoff temperature. The increased loading of these substances to receiving water bodies can be quite detrimental. This chapter discusses the most common contaminants found in urban stormwater runoff, their impacts, and typical concentrations.

---

## 2.1 Impacts of Urban Stormwater

The impact of the increase in urban stormwater runoff volumes and pollutant loads is substantial. Urban stormwater is responsible for about 15% of impaired river miles in the USA (US EPA 2000b) and urban stormwater is the leading cause of pollution to fresh and brackish receiving waters (Mallin et al. 2009). Stormwater impacts can be hydrologic, chemical, biological, or physical, but the impacts of greatest concern are biological integrity and habitat alteration due to the loading of sediment, nutrients, metals, chloride, bacteria, high temperature water, oxygen-demanding substances, and hydrocarbons (US EPA 1992). Although the impacts tend to increase as the urbanization within the watershed increases, negative impacts can be significant in watersheds that are less than 10% urbanized (Pitt 2002).



**Fig. 2.1** Percent impervious surface versus runoff coefficient for watersheds included in the National Urban Runoff Program (NURP) study (US EPA 1983)

### 2.1.1 Flow and Channel Alteration

Urbanization, as reflected by increased impervious surface, alters watershed hydrology in several ways. As shown in Fig. 2.1, for sites studied in the US EPA's National Urban Runoff Program (US EPA 1983), one way is an increase in the runoff coefficient (ratio of inches of runoff to inches of rainfall) as the percentage of impervious surface in the watershed increases. Increasing imperviousness also leads to hydrographs with shorter durations and greater peak flows, larger flood flows, and smaller base flows (Paul and Meyer 2001). Some of the effects of altered flow on biota are due to larger peak temperatures, altered sediment discharge, unstable channels, fewer pools, and degraded habitat due to channelization. Evaluations of stream habitats indicate that flow and channel alteration are major contributors to the observed decline in biological integrity often associated with increased imperviousness (Paul and Meyer 2001; Pitt 2002; Booth et al. 2002; and Schueler 2000a).

### 2.1.2 Nutrients

Nutrients, primarily phosphorus and nitrogen, increase plant growth in streams, reservoirs, and lakes in a process called eutrophication. In many parts of the country, stormwater containing a large concentration of nutrients enters lakes, causing nutrient enrichment, reduced water clarity, and increased presence of

undesirable blue-green algae and other plants. Upon decomposition and oxidation of the plant matter, dissolved oxygen in the water body is consumed, and can be reduced to zero or near zero levels.

Because of urban sprawl, residential land is now the dominant land use in 64% of the nation's water supply reservoirs (Robbins et al. 1991). Eutrophication caused by nutrients in stormwater often impairs municipal drinking water supplies. One example is the New Croton Reservoir, which provides daily drinking water to about 900,000 New York City residents. Due to excessive phosphorus loading, the reservoir suffers from algae blooms, low dissolved oxygen, and poor taste. As a result, it is common for the use of this reservoir to be reduced or temporarily suspended in the summer (NYSAGO 2011).

Excessive nutrient loading can also stimulate the growth of undesirable rooted aquatic plants in streams. The US EPA reports that approximately 11% of the nation's assessed stream miles are threatened or impaired due to excess nutrients (US EPA 2000b). With only 26% of the total stream miles assessed, the total number of stream miles that are threatened or impaired is likely significantly higher.

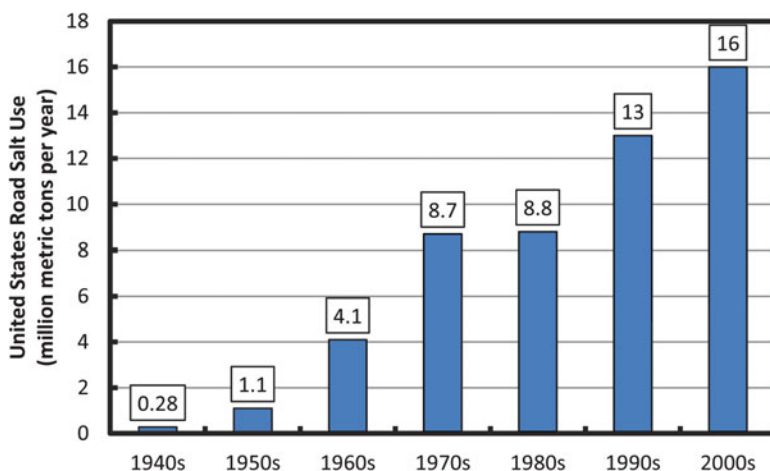
### 2.1.3 Metals

A large number of potentially toxic substances, including metals, occur in stormwater. Metals of primary concern (based on toxicity and occurrence) are cadmium, copper, zinc, and lead (Jang et al. 2005; Rangsviek and Jekel 2005), with roughly 50% of the metal load in dissolved form (Morrison et al. 1983). Lead concentration in the environment has declined since the 1970s, when lead in gasoline and paint was banned, but there is still substantial degrading lead paint present in the urban environment, making this a continuing concern. Note the smaller lead concentration in the three more recent stormwater studies in Table 2.4, as compared with that in the NURP study (US EPA 1983).

Large concentrations of metals can be lethal, and moderate concentrations can reduce growth, reproduction, and survival in aquatic organisms. Small concentrations of metals also have been documented to alter the behavior and competitive advantage of invertebrates, a result that could change the balance of ecosystems (Clements and Kiffney 2002). Kayhanian et al. (2008) investigated the toxicity of stormwater runoff from urban highway sites near Los Angeles, USA. Results indicated that the toxicity to water fleas and fathead minnows of the most toxic samples was mostly, but not entirely, due to copper and zinc.

Once in an aquatic environment, metals can accumulate in freshwater biofilms to such an extent that the biofilm concentrations are larger than sediment metal concentrations. Fish and invertebrates feed on biofilms, as a result, the metals can be transferred through the food chain (Ancion et al. 2010), and bioaccumulation will continue to occur.

Of the stream miles assessed in the USA as of 2011, approximately 7% have been categorized as threatened or impaired due to metals other than mercury. Mercury, which is a metal more common to runoff from industrial land uses and



**Fig. 2.2** Increase in annual road salt use in the USA (NURP) study (US EPA 1983)

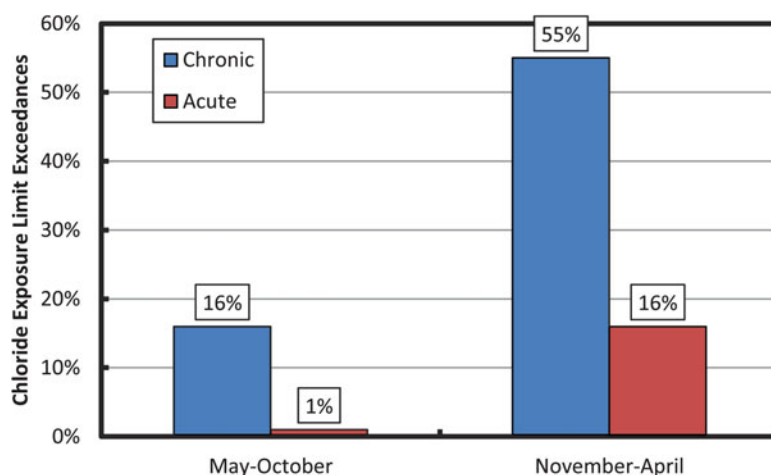
atmospheric deposition, has threatened or impaired approximately 5% of assessed stream miles (US EPA 2011). As more stream miles are assessed, these numbers are likely to increase.

### 2.1.4 Chloride

Chloride is an emerging urban pollutant as a result of road deicing (Novotny et al. 2009). The chloride concentration in streams has been directly correlated with the percent of impervious surface area (Kaushal et al. 2005) and the quantity of rock salt purchases (Novotny et al. 2008). Furthermore, annual road salt use in the USA has continually increased since the 1940s (Fig. 2.2).

After application on a road surface, salt will typically travel to receiving waters, where it can increase the salt concentration of the water body. Peak chloride concentration in winter runoff has been observed close to sea water (35,000 mg/L) at 11,000 mg/L (Corsi et al. 2010), and peak chloride concentration in urban streams during winter can be several thousand mg/L. At these concentrations, chloride can negatively impact the water body. For example, salt increases the density of water, and highly saline waters can settle to the bottom of lakes and alter lake mixing patterns. This process can extend periods of low oxygen in or near the sediment which, in turn, can cause the release of dissolved phosphorus and metals (Wetzel 1975; p. 224). Increased salt concentration can also negatively impact aquatic life by decreasing biodiversity, increasing mortality rates of tadpoles, and decreasing the overall health of organisms (Novotny and Stefan 2010).

The US EPA's acute and chronic water quality limits for chloride in fresh water are 860 mg/L and 230 mg/L, respectively. Studies have found that these limits are often exceeded in northern metropolitan areas during the winter, and less often



**Fig. 2.3** Chloride exposure limit exceedances in summer (May–October) and winter (November–April) for 168 monitoring stations in 13 northern metropolitan areas (Corsi et al. 2010)

during the summer. Exceedance was negligible in all southern monitoring sites (Fig. 2.3).

In the Minneapolis-St. Paul metropolitan region of Minnesota, background chloride concentration in urban lakes was 3–10 mg/L before development, but in 2005, after development, averaged 87 mg/L. Detailed modeling (Novotny and Stefan 2010) has shown that at current road salt application rates, the salt concentration will continue to rise such that some urban lakes will exceed the established chronic standard of 230 mg/L (four-day average) (MPCA 2003) for impairment to aquatic habitat. Clearly, salt concentration in road runoff and surface waters cannot be ignored.

### 2.1.5 Bacteria and Viruses

The potential for bacterial contamination of water is generally measured by the concentration of fecal coliforms, *Escherichia coli*, or enterococci. Although most fecal coliforms are not pathogenic, they are currently the best established representative surrogate, or indicator, of human pathogens.

Rain and increased runoff increase the presence of microbial pathogens in marine and estuarine waters, an effect that can be a direct health threat to humans and can contaminate shellfish. In fact, urban stormwater is the cause of 40% of shellfish closures in US waters (Mallin et al. 2009). In one study, the number of gastrointestinal diseases per 1,000 swimmers was shown to increase linearly with coliform counts (Durfour 1984). One outcome of elevated coliform levels is beach

closings. From 2006 to 2009, 32–43% of beaches nationwide were affected by closings each year (US EPA 2011).

Fecal coliform concentrations are generally largest immediately after rainstorms. A study of Minnehaha Creek in Minnesota (Wenck 2003) reported that fecal coliforms in excess of 2000 CFU/100 mL were found only within 3 days of a rainstorm. Fecal streptococci and *E. coli* were found in 94% and 95.5%, respectively, of municipal separate storm sewer system (MS4) outfalls monitored (Clark and Pitt 2007). This indicates that a large percentage of fecal coliforms are a result of stormwater runoff.

Fecal coliforms are excreted from the bodies of warm-blooded animals. For urban stormwater, sources may include humans (via illicit sewage connections to stormwater conveyances), dogs, cats, geese, raccoons, and other wildlife. Although generation rates (number of coliforms excreted per day) for various organisms (dogs, geese, humans) are well known (Schueler 2000b), there is little information regarding “delivery ratios” (the fraction of excreted coliforms that enters runoff) for urban stormwater.

Potential for groundwater contamination by bacteria and pathogens depends on the soil chemical properties, adsorption capability, the ability of the soil to physically strain the pathogens, and pathogen survival. Bacteria survive longer in low pH (acidic) soils and in soils with large organic content. Bacteria and viruses can move through soil media and may be transported to aquifers by infiltrating stormwater. The transport distance of bacteria seems to be a function of bacteria density and water velocity through the soil (Camesano and Logan 1998; Unice and Logan 2000). Pitt et al. (1996) rate enteroviruses as having high groundwater contamination potential for all surface and subsurface infiltration/injection systems and a variety of other pathogens as having high groundwater contamination potential for subsurface infiltration/injection systems.

Although documented cases of groundwater contamination do exist, bacteria are generally removed by straining at the soil surface and sorption to solid particles. Once removed from the water, the ability of bacteria to survive is a function of factors such as temperature, pH, and presence of metals, among others. Bacteria survival may be between two and three months, but survival for up to 5 years has been documented (Pitt et al. 1999). Although not readily modeled in natural environments, fecal coliforms can also regrow in the environment under warm conditions with a supply of organic matter for food, conditions commonly found in wetlands or stormwater ponds.

As part of the National Urban Runoff Program, fecal coliforms were evaluated at 17 sites for 156 storm events, and based on the results, it was concluded that coliform bacteria in urban runoff may exceed US EPA water quality criteria during and after storm events (US EPA 1999a). There existed a high degree of variability within the data, but land use did not appear to correlate with coliform concentration. During warmer months, concentrations were approximately 20 times larger than cold months.

A study by the National Academy of Sciences (NAS 2000) noted that very large removal rates—on the order of 99% would be needed to reduce coliforms from the levels observed in urban stormwater (15,000–20,000/100 mL) to the EPA’s 200/100 mL criterion for recreational water. Their review indicated that bacterial

**Table 2.1** Comparison of mean bacterial removal rates achieved by different stormwater treatment practices

Bacterial indicator	Bacterial removal rate%		
	Ponds	Sand filters	Swales
Fecal Coliform	65% ( <i>n</i> = 9)	51% ( <i>n</i> = 9)	–58% ( <i>n</i> = 5)
Fecal Streptococci	73% ( <i>n</i> = 4)	58% ( <i>n</i> = 7)	N/A
<i>E. coli</i>	51% ( <i>n</i> = 2)	N/A	N/A

The number (*n*) of practices analyzed indicated in parenthesis (data from NAS 2000)  
N/A = Information not reported in the source

removal rates in several types of stormwater treatment practices were significantly less than 99% (Table 2.1). Studies of coliform regrowth in stormwater ponds have apparently not been reported in the peer-reviewed literature.

2.1.6 Temperature

Urbanization generally requires removing crops, trees, and native plants from parcels of land and replacing them with roads, parking lots, lawns, and buildings. Along with the impacts previously mentioned, these changes in land use affect riparian shading and heating of runoff in these areas, which results in increases in summertime temperatures of nearby streams. This can significantly impact relatively cool waters, such as trout streams that are fed by groundwater, because increases in the volume and temperature of runoff from impervious surfaces will dilute the colder groundwater, lower the volume of groundwater entering the water body, and reduce coldwater fish habitat.

In most temperate climates, the risk to salmon and trout populations due to increased temperature is of concern. Water temperature affects many areas of fish health, such as migration, disease resistance, growth, and mortality (Sullivan et al. 2000).

The US EPA reports that, of the 935,393 stream miles assessed nationwide, approximately 5% (46,786 miles) are threatened or impaired due to thermal pollution (US EPA 2011). With only 26% of the nation’s stream miles assessed, the total length of impaired streams is certain to increase. In a study of 39 trout streams in Wisconsin and Minnesota, stream temperatures increased 0.25°C (0.5°F) per 1% increase in watershed imperviousness (Wang et al. 2003). In Minnesota, no temperature increase is allowed in cold water streams (Class 2A) while warm water streams (Class 2B) are allowed a temperature increase of 3°C (5°F) (MPCA 2003).

The temperature of stormwater runoff is controlled by the initial rainfall temperature and by the heating/cooling processes with the land and other surfaces during runoff. The temperature of land surfaces is controlled by several processes including solar radiation during the daytime, atmospheric long wave radiation, long wave back radiation from the surface, evaporative heat flux, and sensible heat flux. Land surfaces are heated above ambient air temperature primarily by solar radiation. Asphalt and roof surfaces in Minnesota reach daily maximum temperatures that

average 50°C (122°F) in July, while concrete reaches an average of 46°C (115°F) in July (Herb et al. 2007a). Maximum roof temperatures in Mississippi and Wisconsin were found to be over 70°C (158°F), with similar temperatures reported for Arizona, Georgia, Oregon, and Texas (Winandy et al. 2004). Asphalt temperatures in Arizona exceeded 71°C (160°F) in June and July with a mean daily maximum of over 68°C (154°F), while 25% of maximum asphalt temperatures in July and August were over 54°C (129°F) (Harrington et al. 1995).

Land surfaces that are warmed by solar radiation will cool prior to and during storm events, with the amount of cooling depending on the surface properties and the amount of cloud cover prior to the onset of rainfall. Pavement has relatively large thermal mass, and therefore cools off more slowly, while asphalt shingle rooftops cool quickly, and typically reach ambient air temperature by the start of a storm (Janke et al. 2009). Storms with a rapid onset of cloud cover and rainfall after bright sun give less time for land surfaces to cool off, which leads to larger land temperatures at the onset of rainfall and larger runoff temperatures.

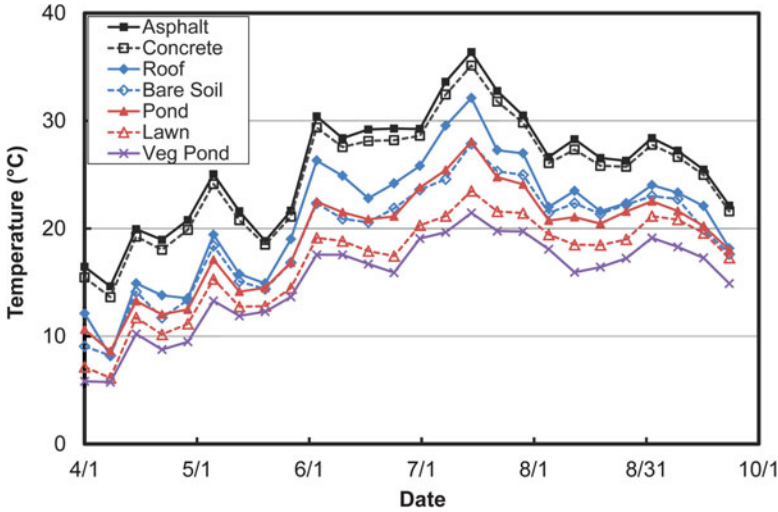
Overall, pavement produces the largest runoff temperatures, which can approach 30°C (86°F) (Herb et al. 2007a; Herb et al. 2008). Tar-gravel commercial rooftops also have sufficient thermal mass to produce large runoff temperatures (Janke et al. 2009). The largest runoff temperatures are typically observed at the beginning of storm events, when the land surfaces are warmest. Because the amount of heat available to heat surface runoff is finite, land surfaces have more impact on runoff temperatures for smaller storms.

Bare soil can produce thermal pollution if the infiltration capacity is exceeded. Vegetated land surfaces are cooler, due to evaporation and the shading effect of vegetation. Figure 2.4 is an illustration of the simulated average weekly surface temperature of five types of land uses in St. Paul, Minnesota, from April to November of 2004, where asphalt weekly surface temperatures are about 18°C (64°F) warmer than grasslands or vegetated ponds in midsummer months. Soil evaporation keeps bare soil surfaces somewhat cooler, with average July maximum temperatures of about 34°C (93°F), and July average temperatures of about 24°C (75°F). Vegetated, pervious surfaces produce relatively little thermal pollution per unit area, because both runoff rates and runoff temperatures are lower than pavement temperatures. Vegetated surfaces, however, can produce thermal pollution for storms of large volume and dew point temperature (Herb et al. 2007a).

### 2.1.7 Oxygen-Demanding Substances

Degradation of organic matter in streams utilizes oxygen, often rapidly enough to reduce the dissolved oxygen concentration to an extent that it impairs aquatic life. Unlike point source discharges that cause the most severe oxygen depletion during low-flow conditions, reduced oxygen concentration due to stormwater in urban streams often occurs just after major storms because of the transport of oxygen-demanding substances into streams.





**Fig. 2.4** Simulated average weekly surface temperature for five land uses calculated with hourly climate data from St. Paul, MN (2004); the vegetated pond represents a pond with fully covered emergent macrophytes (from Herb et al. 2007a)

The amount of degradable organic matter in water is usually quantified by measuring the amount of oxygen that is consumed as the organic matter decomposes or is oxidized. The biochemical oxygen demand (BOD) test measures the amount of oxygen that bacteria consume, typically over a five-day span ( $BOD_5$ ), while decomposing organic matter. Chemical oxygen demand (COD) measures the oxygen consumed in oxidizing all organic matter into carbon dioxide and water, not just that portion that can be oxidized by bacteria. For this reason, COD values are larger than BOD values. Because the COD test oxidizes organic matter with a strong chemical, this test can usually be completed in a day or less, while BOD tests take 5 days.

Some sources of oxygen demand, such as animal waste and decaying vegetation, are natural; others, like oils and greases, grass clippings, and pet waste, are anthropogenic (due to human activity). Mallin et al. (2009) found BOD in urban runoff to be directly correlated with the percent of watershed development and the percent impervious surface cover within a watershed.

Maestre and Pitt (2005) report  $BOD_5$  median values of 8.6 mg/L ( $n = 3,105$ ) and COD median values of 53 mg/L ( $n = 2,751$ ) for approximately 100 municipal separate storm sewer system (MS4) discharge sites throughout the USA, with freeway sites having median values of 8 mg/L ( $n = 26$ ) and 100 mg/L ( $n = 67$ ) for  $BOD_5$  and COD, respectively. Mijangos-Montiel et al. (2010) evaluated contaminant concentrations in runoff from gas stations in Tijuana, Mexico, and compared results to values of contaminant concentrations in runoff from gas stations in urban areas in Washington, DC, USA, and in Genoa, Italy.  $BOD_5$  was not evaluated, but COD values of gas station runoff were 169, 9, and 27 mg/L for

**Table 2.2** Estimated pollutant loads from urban watersheds (from Mijangos-Montiel et al. 2010)

Parameter	Skudai, Malaysia	Johor Bahru, Malaysia	Saskatoon, Canada	Dallas-Fort Worth, Texas, USA	Tijuana, Mexico
Drainage area (ha)	3.3	171.4	616	4–65	2–45
COD (kg/ha)	9.0	12	24	3	54

Tijuana, Washington, DC, and Genoa, respectively. The larger COD values in Mexico were thought to be due to the large fraction of older vehicles in Mexico, which tend to leak more oils, and the fact that gas stations in the USA and Italy undergo more thorough cleaning. Mijangos-Montiel et al. (2010) also compared COD loads from urban catchments in Malaysia, Canada, the USA, and Mexico. Results are shown in Table 2.2.

Oxygen-demanding substances have threatened or impaired 83,580 of the 935,393 assessed stream miles (~9%) in the USA (US EPA 2011). The pollutant load entering these streams is not necessarily from urban stormwater runoff. Loading may originate from agricultural runoff, combined sewer overflows that result in untreated sewage entering the water body, and other natural and/or anthropogenic sources. For example, BOD concentrations in urban stormwater runoff are often less than sewage treatment plant effluent values, which are typically around 20 mg/L. Detrimental effects of urban stormwater runoff BOD have been documented, however. Lee and Jones-Lee (2003) report that urban runoff from a several inch rainfall event caused the dissolved oxygen levels of the San Joaquin River Deep Water Ship Canal to drop from 7 to 9 mg/L to about 3.5 mg/L, and that fish kills coincident to urban runoff from the same storm were associated with low DO levels in nearby rivers.

### 2.1.8 Hydrocarbons

Hydrocarbons are organic compounds consisting entirely of hydrogen and carbon molecules. Hydrocarbons can reduce the ability of some organisms to reproduce, can negatively impact the growth and development of various aquatic species, and can be lethal at high concentrations. For example, fish kills have been attributed to high levels of polycyclic aromatic hydrocarbons (PAHs) (Watts et al. 2010). When consumed, hydrocarbons can bioaccumulate in aquatic organisms, and, when collected in bottom sediment, degradation of hydrocarbons can consume oxygen (Stenstrom et al. 1982), which can negatively impact the entire aquatic ecosystem.

In stormwater runoff, hydrocarbons originate from vehicle coolants, gasoline, oils, lubricants, coal tar-based asphalt sealants (a source of PAHs), atmospheric deposition, and other sources. Thus, gas station runoff and vehicles in general are a major source of the hydrocarbon load in runoff (Mijangos-Montiel et al. 2010). Once in stormwater, hydrocarbons are often associated with particulates (Stenstrom et al. 1982).

2.2 Composition of Urban Stormwater

The chemical composition of stormwater varies with time during a storm event. Pollutant concentration is therefore often represented as event mean concentration (EMC), where the EMC is calculated by (2.1):

$$EMC = \frac{\sum_{i=1}^n C_i Q_i}{\sum_{i=1}^n Q_i}$$

(2.1)

where

- $Q_i$  = flow during interval  $i$
- $C_i$  = concentration during interval  $i$

Median concentrations of relevant stormwater constituents are provided in Tables 2.3 and 2.4. Two major analyses of urban stormwater throughout the USA (US EPA 1983; Maestre and Pitt 2005) show that EMCs vary significantly among storms and that relationships between annual median EMC and land use are weak. The values in Tables 2.3 and 2.4 should therefore be used only as approximations. Field measurements are required to determine the actual concentration of a given constituent for a particular watershed and rain event.

Table 2.3 Composition of urban stormwater concentrations of major constituents

Metropolitan area	TSS	VSS	TP	DP	COD	BOD	TKN	NO <sub>3</sub> -N	NH <sub>4</sub>
Minneapolis-St. Paul, MN	184	66	0.58	0.2	169	N/A	2.62	0.53	N/A
Marquette, WI	159	N/A	0.29	0.04	66	15.4	1.5	0.37	0.2
Madison, WI	262	N/A	0.66	0.27	N/A	N/A	N/A	N/A	N/A
USA cities (median for all sites)	100	N/A	0.33	0.12	65	9	1.5	0.68	N/A
USA MS4 discharge sites (median for all land use)	58	N/A	0.27	0.13	53	8.6	0.6	N/A	N/A
California highway runoff (median for all sites)	59.1	N/A	0.18	0.06	N/A	N/A	1.4	0.6	N/A

Minneapolis-St. Paul, MN, mean EMC (Brezonik and Stadelmann 2002)  
Marquette, geometric means (Steuer et al. 1997)  
Madison, geometric means (Waschbusch et al. 1999)  
USA cities, medians (US EPA 1983)  
USA MS4 discharge sites (Maestre and Pitt 2005)  
California highways, medians (Kayhanian et al. 2007)  
N/A = Information not reported in the source

Note: All values are in mg/L. *TSS* = total suspended solids, *VSS* = volatile suspended solids, *TP* = total phosphorus, *DP* = dissolved phosphorus, *COD* = chemical oxygen demand, *BOD* = biochemical oxygen demand, *TKN* = total Kjeldahl nitrogen, *NO<sub>3</sub>-N* = nitrate nitrogen, *NH<sub>4</sub>* = ammonium

**Table 2.4** Composition of urban stormwater metals (mg/L) and coliforms (#/100 mL)

Metropolitan area	Total lead	Total zinc	Total copper	Total cadmium	Coliforms
Minneapolis-St. Paul, MN	0.060	N/A	N/A	N/A	N/A
Marquette, WI	0.049	0.111	0.022	0.0006	10,200
Madison, WI	0.032	0.203	0.016	0.0004	175,106
USA cities (median for all sites)	0.144	0.160	0.034	N/A	21,000
USA MS4 discharge sites (median for all land use)	0.016	0.117	0.016	0.001	12,000
California highway runoff (median for all sites)	0.0127	0.1112	0.0211	0.00044	N/A

Minneapolis-St. Paul, mean EMC (Brezonik and Stadelmann [2002](#))

Marquette, geometric means (Steuer et al. [1997](#))

Madison, geometric means (Wachbusch et al. [1999](#))

USA cities, medians (US EPA [1983](#))

USA MS4 discharge sites (Maestre and Pitt [2005](#))

California highways, medians (Kayhanian et al. [2007](#))

N/A = information not reported in the source

<http://www.springer.com/978-1-4614-4623-1>

Optimizing Stormwater Treatment Practices  
A Handbook of Assessment and Maintenance

Erickson, A.J.; Weiss, P.T.; Gulliver, J.S.

2013, XII, 337 p., Hardcover

ISBN: 978-1-4614-4623-1