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Green Infrastructure Research: Permeable Pavement at EPA's Edison Environmental Center

Figure 1. Aerial view of EPA's Edison Environmental Center permeable parking lot: (A) permeable interlocking concrete pavers, (B) pervious concrete, (C) porous asphalt, (D) conventional asphalt.

- Three types of surfaces:
  - Permeable interlocking concrete paver
  - Pervious concrete
  - Porous asphalt
- Instrumented to monitor:
  - Infiltrating water and interaction with underlying soil
  - Surfaces' ability to accept water
  - Water quality
  - Usage and maintenance effects
- Lined and unlined sections for capture and monitoring of infiltrating water
- Conventional asphalt driving lanes to allow for runoff to permeable surfaces
- Runoff from conventional asphalt at south end feeds rain garden
- Surfaces are exposed to the same conditions for direct comparison

Figure 2. Key permeable parking lot design features at EPA's Edison Environmental Center.

Background

Stormwater runoff from urban or paved areas can pollute receiving waters and cause flooding and erosion. A type of green infrastructure, permeable pavement systems reduce runoff volumes by allowing stormwater to drain through a paved surface, recharging groundwater supplies. Pollutants may be removed as the water moves through the underlying materials.

While the number of permeable pavement systems is growing, there is a lack of research on side-by-side comparisons of full-scale, outdoor systems that are actively-used. Studies of permeable pavement operating in its intended use are necessary to determine performance, required operations and maintenance, and water quality impacts.

Research Objective

EPA scientists are evaluating permeable pavement as part of a long-term research effort examining stormwater management practices. The objective of the research is to simultaneously demonstrate and document the performance and capabilities of three permeable pavement systems: permeable interlocking concrete pavers (PICP), pervious concrete (PC), and porous asphalt (PA); and determine water quality impacts.

Approach & Methods

In 2009, EPA installed a permeable pavement parking lot at its Edison Environmental Center in New Jersey. The lot, designed to be monitored as a long-term research effort, is in regular use by facility staff and visitors. The 43,000 sq. ft. parking lot has three types of permeable surfaces across 110 stalls in five rows (Figure 1). Figure 2 summarizes the lot's key features.

Each of the permeable parking rows has sections with impermeable liners to collect the infiltrating water and pipes that transport it to a collection tank. Unlined sections allow stormwater to infiltrate to the underlying soil, and instruments monitor accumulated water depth, movement, and temperature.

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Table 1. Key research results from EPA's Edison Environmental Center permeable parking lot.

Monitoring Objective	Parameters Measured	Key Results
Hydrologic performance	Volume, exfiltration rate, infiltration rate (IR)	• PC has largest infiltration rate; PA has lowest. • Infiltration rate decreases with increasing thickness.
Water quality performance	Solids, indicator organisms, metals, nutrients, semi-volatile organic compounds	• Permeable pavement systems do not reduce total nitrogen. • Total nitrogen concentration in PA infiltrate was higher than rainfall, other surface infiltrate, or runoff concentration, a finding unique to this study. • Orthophosphate concentration in infiltrate from PA was smaller than in rainwater, runoff, and infiltrate from PICP and PC.
Urban heat island effects	Net radiation, infrared radiation, temperature	• 5 to 7% of infiltrate evaporates, which may help mitigate heat island effects.
Maintenance effects	Surface infiltration rate, visual assessment	• Instruments monitor surface clogging and infiltration capacity, providing insight as to when maintenance is needed. • Surface clogging occurs over time as sediment in runoff blocks infiltration pathways and reduces infiltration rates.
Use	Visual assessment	• PC breakdown (raveling) began occurring after five years.
Infiltrating water parameters	Water depth, redox, pH, conductivity, chloride	• Chloride is trapped in pavement and flushed out over time, persisting longest in PA and releasing fastest from PC. • Acidic rainwater became basic as it infiltrated through each permeable pavement profile; PA infiltrate had highest pH.

Results

The performance of the systems vary, and key research results are summarized in Table 1. Despite variation among pavement types, any of these permeable pavements should adequately infiltrate not only direct rainfall but additional run-on from adjacent areas (Brown and Borst 2014).

Researchers observed effects on water quality from nitrogen, and from chloride, after road salt application. PA infiltrate had a larger total nitrogen concentration than both runoff and infiltrate from the other pavement types. This indicates that nitrogen leached from materials in this PA strata, a finding unique to this study (Brown and Borst 2015). After chloride (road salt) application, some chloride is temporarily trapped in the permeable pavement surface and underlying aggregate, but is flushed during subsequent rainfalls. Chloride was found in the infiltrate in measurable amounts throughout the year, with reported concentrations at levels more than ten times the national recommended aquatic life criterion (Borst and Brown 2014). Chloride was also attributed to the breakdown of the PC.

Impact

The EPA Edison parking lot facilitates the investigation of the design and performance of permeable pavement systems. This research provides needed design, performance, and water quality impact information to enable communities to make better stormwater management decisions. This research confirms that all three types of surfaces studied (PICP, PC, and PA) are viable options for infiltrating both rainfall and stormwater run-on.

Decision makers have the challenge of evaluating these benefits against water quality impacts, which can be significant. Increased nitrogen released from PA can lead to eutrophication in surface water systems. The year-around release of chloride from all permeable pavement types causes elevated levels in surface waters, which can negatively affect aquatic species. EPA is continuing to research and communicate about permeable pavement design, performance, and water quality impacts.

In addition to its use as a field research site, the parking lot is used as a demonstration site to teach visitors about permeable surfaces. It also contributes to EPA's greening strategy to reduce the environmental impact of the Agency's facilities and operations.

References

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Additional Information

EPA's Green Infrastructure Research: epa.gov/water-research/green-infrastructure-research

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