TECH. NOTE

Highlights from The International BMP Database 2020 Summary Report

Stormwater Equipment Manufacturers Association

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HIGHLIGHTS FROM THE INTERNATIONAL BMP DATABASE 2020 SUMMARY REPORT

ABSTRACT:

This technical note highlights the results from the International BMP Database 2020 Summary Report that relate to the performance of manufactured separators and filters.

Background:

Over the past twenty-five years the International BMP Database (IBMPDB) has become the most complete source of information on stormwater quality control measures available to researchers and regulators. Comprised of user submitted BMP monitoring projects, this repository provides access to both raw data and statistical tools to interpret hundreds of studies and thousands of storm events. The database is funded by the Water Research Foundation and other partners[1] and is administered by a network of environmental professionals from consultancies such as Wright Water Engineers, Inc., Geosyntec Consultants, Inc., and Terraphase Engineering, Inc.

Although monitoring guidelines are provided by the IBMPDB research team, the IBMPDB is not a testing or verification program. Studies are completed under a variety of real-world field conditions, vary in number of storms, may have challenging site constraints, and have varying levels of maintenance, which make side by side comparison from study to study somewhat difficult. The IBMPDB compensates for this limitation with a large and varied data set. When there is sufficient data to infer statistical trends, the research team publishes summary reports that provide a meta-analysis of the data. These reports also aim to consolidate the data into a few actionable messages.

Hydrodynamic separators had been studied and included in the database in the past, but the 2020 Summary Report was the first for which there was enough data to also include separate statistics for manufactured filters and manufactured biofiltration systems. These manufactured systems typically operate at a higher hydraulic loading rate than generic systems like sand filters or in-situ bioretention cells. Although the manufactured filters and biofilters showed similar performance to non-proprietary filters and biofilters with regards to metals removal and nitrogen removal, they demonstrated standout performance in the removal of TSS and phosphorus. This document highlights the performance of manufactured BMPs in these areas and provides some context for the results.

[1] The project began in 1996 under a cooperative agreement between the American Society of Civil Engineers (ASCE) and the U.S. Environmental Protection Agency (USEPA). In 2004, the project transitioned to a more broadly supported coalition of partners now led by the Water Research Foundation (WRF), including the Federal Highway Administration (FHWA), American Public Works Association (APWA), and the Environmental and Water Resources Institute (EWRI) of ASCE.

TSS TREATMENT

Total Suspended Solids (TSS) is the most regulated pollutant in stormwater, and it follows that all of the BMP types studied demonstrated statistically significant reductions of TSS. However, as illustrated in Figure 1 below, the lowest median TSS effluent concentrations were observed in bioretention (BR), media filters (MF), high rate biofiltration devices (HRBF), and retention ponds (RP). Other treatment facility categories studied include detention basins (DB), retention ponds (RP), wetland basins (WB), grass swales (BS), grass strips (BI), high rate media filters (HRMF), hydrodynamic separators (HDS) and oil/grit separators (OGS).

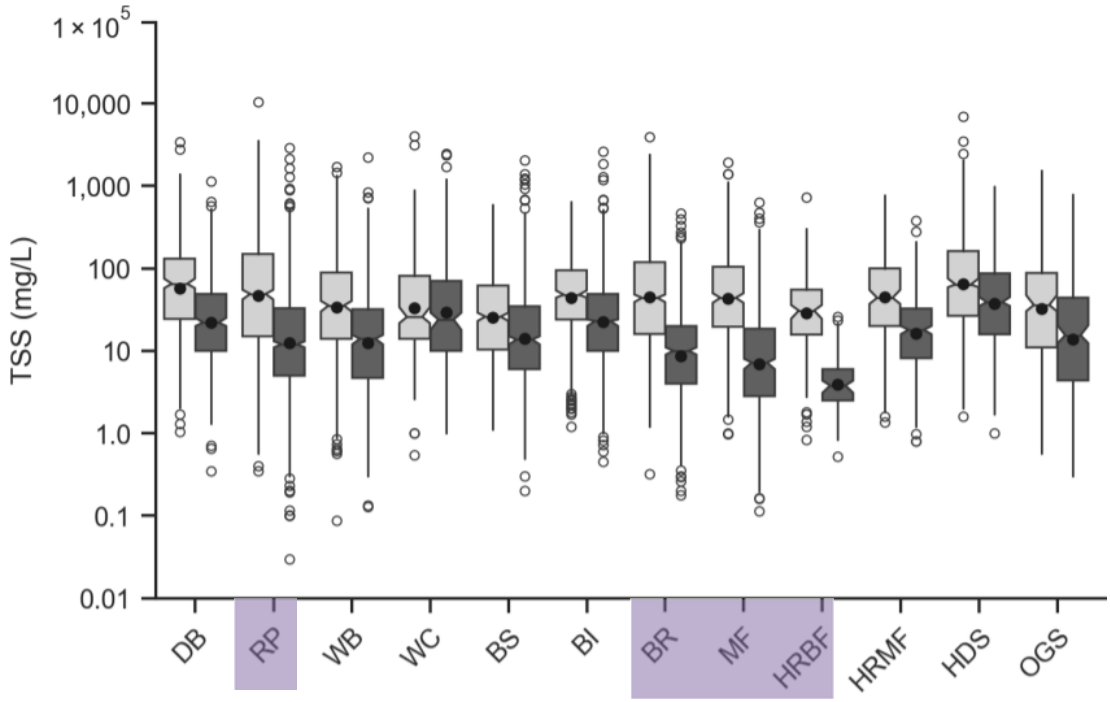

Figure 1: Box and whisker plots with best performing BMPs highlighted. Source: Clary et al. 2020. p.17, Reprinted with permission. © The Water Research Foundation.

Of those four top performers, high rate biofiltration devices showed the lowest median effluent concentration with a median of 3.8 mg/L. High rate biofiltration devices are manufactured planter boxes with custom engineered media blends designed to receive and treat stormwater at flow rates of 100 inches per hour or higher. This technology class uses custom blends of sand, gravel and organic material to ensure plant health while maintaining a high treatment flow rate. Many of these systems undergo laboratory and field test certification to verify performance and longevity. Additionally, the manufacturers of these systems manage the sourcing and quality control of the filter media, removing much of the risk associated with installation of bioretention systems.

One way to compare the relative sizing of high rate biofiltration to non-proprietary biofiltration is to compare the ratios of filter areas to drainage areas. In the 2013 report "Influence of Design Parameters on Achievable Effluent Concentrations", the biofiltration systems surveyed had area ratios generally ranging from 0.04-0.07. Area ratios for high rate biofilters are often ten times smaller, allowing for more compact filter installations.

Hydrodynamic separators are another class of manufactured BMP described in the 2020 Summary report. While the data for this class of BMPs shows higher effluent concentration than other systems, it is worth noting that these systems are often sized for pre-treatment of runoff upstream of other stormwater control measures, and are used for removal of coarser material at higher influent concentrations. Although hydrodynamic separators might not remove fine sediment as effectively as filters, they are often specified due to their easy maintenance and compact footprint.

The hydrodynamic separator data in the 2020 Summary Report draws on studies conducted from 1996-2011 and is starting to become dated. In recent years, testing for HDS systems has shifted to laboratory-based protocols such as the New Jersey Department of Environmental Protection protocol, but the database does not currently include the more current laboratory studies. The NJDEP protocol tests the flow rate at which a separator can remove 50% of influent TSS, and is designed to be an appropriate measure for evaluating a pre-treatment device.

To consider the IBMPDB data with regards to pre-treatment, Figure 2 below shows the average removal efficiency if the database is truncated at a specific influent concentration. For example, while the average paired removal efficiency for the entire data set is 20%, if only the data pairs with influent concentrations higher than 200 mg/L are considered, the average removal efficiency is 52%. Although likely coincidental, this correlates with the New Jersey Department of Environmental Protection test protocol that calls for 50% removal of a 200 mg/L influent concentration of test sediment. At influent concentrations lower than 200 mg/L, removal efficiency drops off quickly.

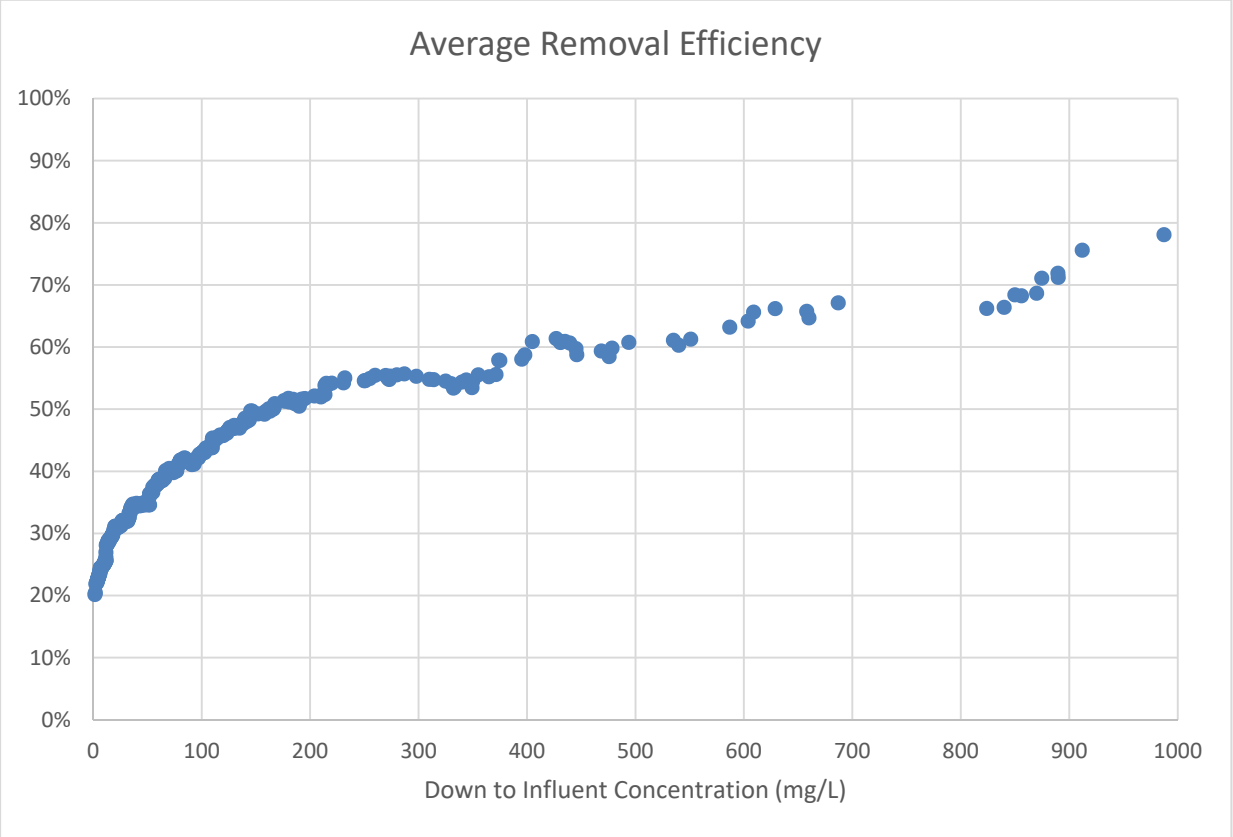

Figure 2: Average removal efficiency of the HDS paired data sets truncated at a range of influent concentrations. For example, the average removal efficiency for the data with influent concentrations greater than 200 mg/L is 52%.

The reason for this reduction in performance at low influent concentrations is not known with certainty, but it is known that smaller particles mobilize more easily than larger particles when storms occur. In a field study with a low influent concentration, the TSS load is often skewed toward finer material that is harder to capture in an HDS system. In other words, the influent runoff will pick up fine material first, so the initial lower concentrations will contain proportionally more fine material. As a result of this, hydrodynamic separators have become less frequently employed as a terminal treatment option and are more likely used as pre-treatment or in redevelopment and roadway applications where space constraints are common.

PHOSPHORUS TREATMENT

Three BMPs were recognized in the 2020 Summary Report as best choices for removing phosphorus: media filters (MF), high rate biofiltration (HRBF) and high rate media filtration (HRMF). Two of the three categories, high rate biofiltration and high rate media filtration, are comprised of manufactured treatment systems. As described above, "high rate biofiltration" describes manufactured devices containing a manufactured high rate biofiltration media that supports plants while quickly filtering runoff. The product category identified as "high rate media filtration" is a catch-all term for all manufactured bed filters, cartridge filters and membrane filters that rely on a specific type of media to filter pollutants. These systems do not generally support plants or the biological activity that results from the presence of plants. A performance comparison of all BMP categories included in the summary report can be seen in Figure 3.

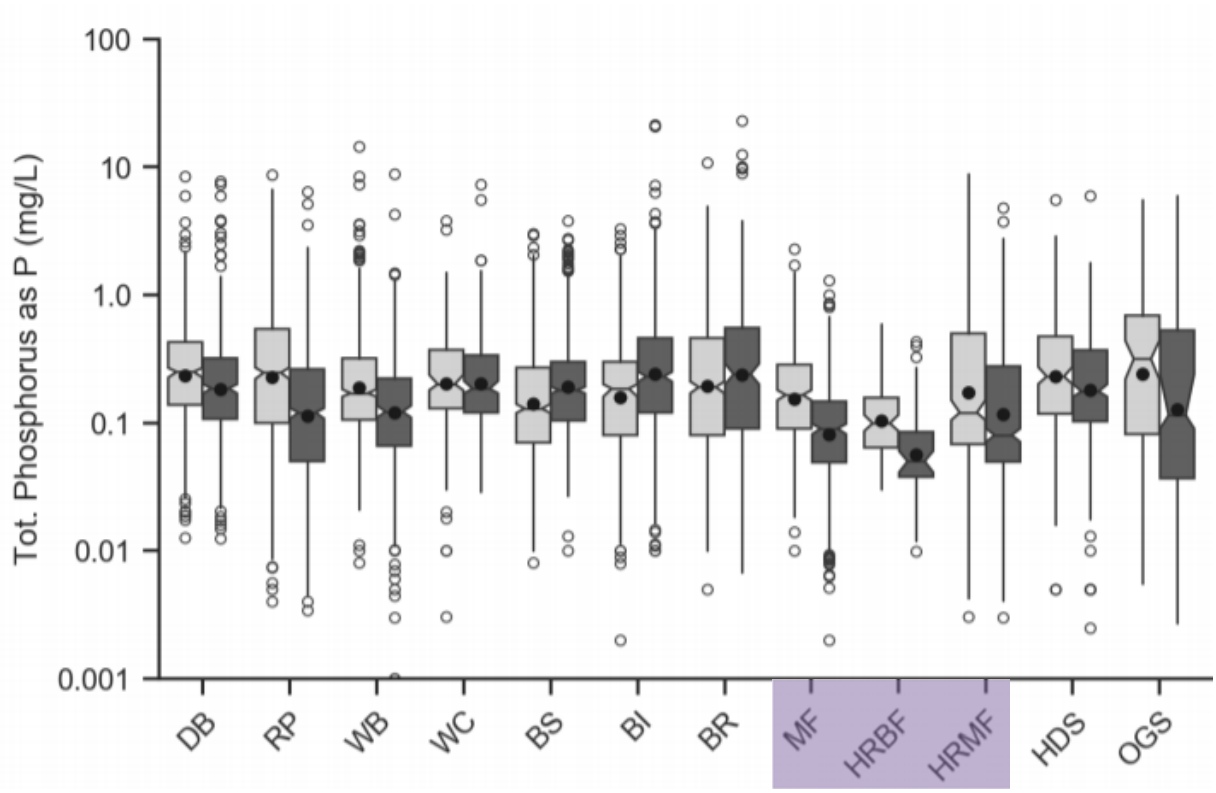

Figure 3: Box and whisker plots with best performing BMPs highlighted. Source: Clary et al. 2020. p.45, Reprinted with permission. © The Water Research Foundation.

The median effluent concentrations of Total Phosphorus from the media filters, high rate bioretention filters and high-rate media filters were 0.09 mg/L, 0.05 mg/L, 0.08 mg/L, respectively. All other commonly used BMPs studied showed median effluent concentration higher than 0.1 mg/L.

While this chart is useful for comparing performance, it doesn't capture the comparative hydraulic loading rates of the top performing systems. Typical loading rates for media filters and high rate biofiltration systems may be around one gallon per minute per square foot of filter surface area. High rate media filters are often loaded at rates 3-5 times higher than traditional filters, resulting in more compact treatment systems for a given catchment as well as providing the lowest observed effluent.

Additionally, it should be noted that phosphorus export was observed in some of the most common green infrastructure practices such as grass swales and traditional bioretention systems. It is hypothesized that this export is due to the presence of phosphorus rich soils and organic materials added to the media blends that are prone to leaching. The authors of the 2020 Summary Report recommend that contractors installing green infrastructure pay careful attention to the phosphorus content of media components, such as the addition of compost. This finding highlights a need to mitigate the risk of unwanted organic material in BMPs installed in-situ by contractors. Due to consistent media quality control and blending, this risk is not an issue with manufactured systems.

INFILTRATION AND LOAD REDUCTION

In a conversation about this paper, Jane Clary, a principal investigator on the 2020 Summary Report team, suggested that a comparison of effluent concentrations is only part of a system's performance. Infiltration and other volume reduction measures will also reduce the total pollutant load, regardless of effluent concentrations. "For example, a non-proprietary bioretention facility may not show a phosphorus concentration reduction, but it might have a substantial volume reduction", says Clary.

Volume reduction is discussed in the 2020 Summary Report as a method to treat otherwise difficult pollutants such as bacteria and total dissolved solids, with some cautions provided for especially mobile dissolved solids such as road salt. Similarly, infiltration is presented as a useful method of reducing nutrients, provided that the local groundwater conditions can receive the additional load and the native soils onsite are suitable for infiltration. In many areas, protection of groundwater is of equal or greater importance than the protection of receiving waters.

The 2020 Summary Report does not include infiltration in its analysis, but the 2012 Analysis of Volume Reduction in Bioretention BMPs provides a summary. The analysis showed a wide range of infiltration rates of anywhere from 10% to 100% of the runoff volume depending on a variety of site-specific factors and system design features. Some of these performance modifying features are easy to specify, such as the inclusion of an underdrain, and can be added to any BMP. Other factors are influenced by multiple stakeholders and are more complicated to manage, such as on-site soils and weather, installation methods and maintenance routine.

CONCLUSIONS

The following conclusions were noted when interpreting the 2020 Summary Report for the International Stormwater BMP Database:

- Median TSS concentrations in the effluent from manufactured high rate biofiltration systems were shown to be 6.2 mg/L lower than non-proprietary biofiltration systems. The higher hydraulic loading rates of these manufactured systems also result in comparatively smaller filter system sizes.

- Manufactured filters such as high rate biofiltration and high rate media filters were observed to produce a lower effluent concentration of total phosphorus than bioretention, retention ponds grass swales or wetland basins.

- By allowing for better control over the planting media composition, manufactured high rate biofiltration can provide a reduced risk of phosphorous export over contractor installed bioretention.

- Volume reduction from infiltration can assist in the overall reduction of pollutant load, but performance varies widely based on site conditions, system design, installation and maintenance.

- The data in the IBMPDB should be screened for conditions or influent concentrations suitable for the BMP type or application. The database is not all inclusive and averages don't necessarily represent performance for any specific technology or BMP. Also, the database does not include current HDS data from field or laboratory testing.

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