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Determination of best management timing of nonpoint source pollutants using particle bins and dimensionless time in a single stormwater runoff event

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ABSTRACT

Efforts to alleviate nonpoint source (NPS) pollution contributing to the degradation of water quality in aquatic environments have increased over the last several decades. In this research, dimensionless time (τ_{DL}) and particle size bins were applied as indicators to optimize the management timing for NPS pollutants. Field experiments that included four single storm events and two multiple storm events were conducted in order to measure the flow and to collect water samples for the analysis of particle size bins at each monitoring site. Particle bins for all samples were measured using an LS230 laser diffraction particle size analyzer. An analysis of variance (ANOVA) test was carried out to statistically identify the importance of τ_{DL}. By considering the particle size bins of NPS pollutants during a single stormwater runoff event, these results showed that τ_{DL3} which is triple time of τ_{DL1} after τ_{DL0} optimized the flow management timing. ANOVA and *post hoc* tests further confirmed that τ_{DL3} can be viewed as an equivalent time for the end of particle discharge during a single storm event. In practical terms, this study thus suggests that the volume of first-flushed stormwater captured prior to τ_{DL3} is an important criterion for best management practices. It is also expected that the methodology proposed in this research using particle bins and τ_{DL3} can be further extended to different drainage areas and land uses.

1. Introduction

The quantitative management of nonpoint source (NPS) pollution is a function of hydrological parameters, such as runoff depth, the time for stormwater runoff, and other properties, including the discharge concentrations of NPS pollutants (Stephenson et al., 1998). Over the last several decades, methods attempting to quantify NPS pollution, such as pollutant loading, event mean concentrations (EMCs), and dynamic EMCs, have been developed using hydrological flows and pollutant concentrations (Kim et al., 2007). These methods were typically applied to assess the characteristics of NPS discharges and loadings into streams or lakes and to determine the relationships among runoff volume, NPS pollutant concentrations, and meteorological conditions (Brezonik and Stadelmann, 2001). Results obtained using these methods revealed that NPS discharges are indeed related to meteorological conditions, including rainfall intensity, rainfall depth, and antecedent dry days (ADDs), and that they subsequently affect the efficiency of structural best management practices (BMPs) for constructed wetlands and infiltration systems (Carleton et al., 2001; Persson and Wittgren, 2003). Structural BMP devices have been generally designed and constructed in attempts to control NPS pollution because of the benefits, such as pollutants removal and flood control (Park and Roesner, 2012). According to the USEPA guidelines for structural BMP designs, there are four major concepts for designing structural BMP devices: (1) BMP performance goals and objectives, (2) hydrological design concepts, (3) flood and peak discharge control strategies, and (4) water quality management strategies. Most guidelines, such as the EPA guideline, mention the importance of stormwater volume and quality; however, some structural BMP devices—over the few decades that they have existed—have been used more to reflect the hydrological variables related to stormwater volume, such as runoff depth, soil permeability, and drainage area. These

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