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Research article

Public perception towards river and water conservation practices: Opportunities for implementing urban stormwater management practices

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ABSTRACT

The effectiveness of urban stormwater management practices (SMPs) on local water quality is dependent on adoption rates reaching a critical mass. While numerous studies have measured the effectiveness of practices on controlling water quantity and improving water quality, few have focused on the perspective of the public. The purpose of this study was to identify individuals' perceptions of urban SMPs implementation in the public and private realms, and how longitudinal perceptions about the local river could inform future water resource management. Through the lens of environmental behavior theories, we performed statistical analyses on four surveys – 2006, 2009, 2014 and 2016 – administered to urban residents in the Wabash River watershed in Tippecanoe County, Indiana. Our findings show that residents' water quality awareness and sense of personal responsibility increase over the ten years studied. In particular, rain garden adopters have higher appreciation of the Wabash River and care about how the river functions than other SMP adopters and non-adopters. In terms of urban SMP adoption, results indicate that residents are supportive of integrating rain barrels and rain gardens into public spaces. Perceptions of SMP benefits related to functional benefits, rather than environmental benefits, are prevalent when considering implementing SMPs on personal property. In addition, respondents support reducing stormwater charges for adopters of such practices on private property. Although cognitive barriers exist in those who have yet to adopt the practices, including concerns about SMP effectiveness, maintenance, aesthetics, and risk of bugs and insects, adopters are less likely to perceive such barriers. This research suggests that making resources (i.e., skills, knowledge, equipment, funding) more accessible to the public is essential, but not sufficient to encourage pro-environmental behaviors. Promoting public involvement in watershed activities, increasing their awareness about how urban SMPs function, and emphasizing the functional benefits of practices can be effective in motivating adoption.

1. Introduction

Stormwater runoff is a dominant cause of urban water problems, including the degradation of water quality, disruption of hydrologic function, and disturbance of biological habitat (Walsh et al., 2005). Urban stormwater runoff carries pollutants, such as excess fertilizers and pesticides used on residential lawns and toxic chemicals from business and industrial areas, over roads, streets, parking lots and other impervious surfaces, and into streams, rivers, lakes, wetlands and groundwater (USEPA, 2017). The most recent National Water Quality Inventory Report recognized urban runoff as the leading source of water quality impairments to surveyed estuaries (USEPA, 2009a). Walsh et al. (2012) identified urban stormwater runoff as an environmental flow problem, which increases frequency of overland flow and magnitude of peak flow during stormwater events. This environmental flow problem has a negative impact on water quality due to elevated concentrations of sediments and pollutants. In addition, poorly managed urban stormwater runoff increases the public's vulnerability to flood hazards (Konrad, 2003) and risk of waterborne diseases (Gaffield et al., 2003). Conventional combined drainage systems consist of catch basins and end-of-pipe structures that deliver water to nearby water bodies, however these have caused severe issues of bank erosion, channel morphology and downstream flooding (National Research Council, 2009), as well as exacerbated hydrological disturbance.

Urban stormwater management practices (SMPs), such as rain barrels, rain gardens, and pervious pavement, can reduce peak volume and velocity of stormwater runoff to streams (USEPA, 1999). These practices are suitable for capturing, detaining, and infiltrating stormwater runoff on lot-size sites. Because these urban SMPs are installed predominantly on lot-size areas, they are also called decentralized

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practices, as compared to conventional drainage solutions that typically entail a centralized water treatment system. A rain barrel is a kit used to collect and store rainwater via a downspout from a rooftop. One 55-gallon rain barrel, which can be filled in a one-quarter inch rainfall event, would save up to 1000 gallons of water from a typical single-family residential home rooftop (1000 square feet) with two inches of rainfall (Sustain Dane, 2017). A rain garden that is designed to capture one inch of roof runoff could retain 99% of rainwater from 1150 square feet of a roof, while filtering the majority of pollutants (Dietz and Clausen, 2005). Pervious pavement, consisting of either gravel infill (Gilbert and Clausen, 2006) or concrete paver blocks (Collins et al., 2008), resulted in lower runoff volume and pollutant concentration than asphalt driveways.

Though a significant number of studies are available on the benefits of urban SMPs, only a few studies have investigated individuals' perceptions about the approach and factors that influence its adoption. We identified 235 studies about urban SMP implementation published from 1982 to2017[1] and performed an automatic content analysis[2] to determine prevalent themes. We found that over half of the papers focused on the engineering design of practices, and the most frequent thematic word from these papers was “model.” The models described in these studies are mostly used to assess the effectiveness of urban SMPs for addressing the impacts of land use change and climate change. However, the actual effectiveness of urban SMPs is dependent on adoption rates reaching a critical mass. Our research focuses on social dimensions of urban SMP implementation and explores perceptions of a local waterbody that we argue represents environmental awareness and sense of responsibility for water resource protection. In this study, we measure public opinion on urban SMPs and analyze perceptions towards a local water body over the last decade through longitudinal social indicator surveys. We answer the following questions:

- What are the concerns of individuals regarding the integration of urban SMPs into public space?
- What are the concerns of individuals regarding the implementation of urban SMPs on their own properties?
- What are the implications of longitudinal public perceptions of the local river on water resource management?
- Is there a relationship between public perceptions of the river and adoption of urban SMPs?

We assess public opinion on urban SMPs through the examination of attitudes towards the integration of practices into public areas, perception of practices' features or benefits, concerns about adopting the practices, and opinions of the regulations and policies relevant to urban SMPs. We evaluate public perception of the local river by measuring environmental awareness of local water quality issues, local improvement efforts, and sense of personal responsibility. We then examine if there is a difference between people with different experiences with urban SMPS and their attitudes towards the river. We hypothesize that people who currently use urban SMPs will be more likely to perceive positive benefits from the practices and feel a sense of responsibility to protect the river. People who are somewhat familiar with the practices will perceive certain concerns towards the practices and feel less responsibility toward the river. The results inform our recommendations for water resources planners to promote the adoption of urban SMPs and improve water resource management.

2. Background

2.1. Challenges of urban stormwater management

Urban SMPs employ control and treatment measures to mitigate water runoff and break down pollutants using a natural approach. Decentralized urban SMPs, also called parcel-size or lot-size practices, mimic natural processes by containing, harvesting and filtering water through practices such as native planting, rain barrels, rain gardens, bioswales, and pervious pavement. Urban SMPs are known by diverse names around the world: they are often known as stormwater Best Management Practices (BMPs) and Low Impact Development (LID) in the US, Sustainable Urban Drainage System (SUDS) in the UK, Alternative Techniques (AT) in France, Water Sensitive Urban Design (WSUD) in Australia, and Green Infrastructure (GI) in many other countries (see the evolution of these urban drainage terms in Fletcher et al., 2015). Marsalek and Chocat (2002) recognized that the adjectives “best,” “alternative” and “sustainable” are not well defined in each term, and such terms do not always represent identical concepts: they could refer to individual or grouped measures for stormwater management or for the entire drainage system. This paper will use urban stormwater management practices (SMPs) to represent rain barrels and rain gardens studied in this research.

Researchers have explored challenges of urban stormwater management through an institutional (top-down), rather than individual lens. Traditionally, top-down approaches are used to investigate obstacles to urban SMPs by first examining challenges that stem from institutional structures and then looking at how those structures influence policies and programs. Roy et al. (2008) identified technical problems of urban SMPs, such as performance uncertainty and insufficient engineering standard, as well as institutional barriers, including lack of legislative regulations, fragmented governmental responsibilities and inadequate funding. Notably, the authors found that both practitioners and the general public were resistant to SMP implementation. The reasons they identified included cost penalty risk, risk of failure, and maintenance requirements. However, the factors influencing the public's resistance to change were not well explored in the Roy et al. (2008) study. Other research has concluded slight differences in barriers to SMP implementation. Through an extensive literature review, Brown and Farrelly (2009) concluded that socio-institutional barriers, such as institutional inertia and complex institutional framework, rather than technical barriers, were major challenges to urban SMP implementation. Dhakal and Chevalier (2017) found most implementation obstacles were from “cognitive limitations and socio-institutional arrangements” (page 172), including hierarchical policy barriers (i.e., federal, state, city), resource barriers (i.e., financial resources, human resources, information resources), and cognitive barriers (i.e., cost and performance risk, reluctance to change, unawareness, etc.). These studies synthesized challenges for urban stormwater management largely from a political and governmental perspective (Chaffin et al., 2016; Fitzgerald and Laufer, 2017; Irga et al., 2017; Keeley et al., 2013). However, such top-down methods neglect a consideration of the public's acceptance and concerns regarding the implementation of SMPs. Indeed, few empirical studies have examined concerns and issues individuals might encounter when implementing decentralized urban SMPs in both private property and public spaces. Mankad and Tapsuwan (2011) summarized research on understanding social drivers of decentralized water systems is needed, especially public attitudes and adoption behaviors towards urban SMPs. Investigating people's attitudes towards urban SMPs fills an important research gap – understanding public perceptions can inform effective urban SMP programs and policies that may increase adoption on private land and increase acceptance for SMPs in public spaces.

[1] Search words included terms specific to: 1) urban SMPs (stormwater conservation practices, best management practices, green infrastructure, low impact development); 2) the decentralized lot-scale (residential, household, urban); and 3) individual actions (adoption, implementation, installation). The search did not limit journal sources, publication year, or document types; however, we searched for English only sources. The initial search retrieved 412 studies, and 177 were excluded as irrelevant through examination of each abstract.

[2] Automatic content analysis is a text-parsing machine learning tool, using probabilistic topic model algorithms to discover the thematic composition of a body of literature (Nunez-Mir et al., 2016).