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Research article

Behaviour change: Trialling a novel approach to reduce industrial stormwater pollution

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ABSTRACT

The evidence base for the performance and effectiveness of non-structural measures to manage stormwater pollution in industrial areas is relatively underdeveloped, despite their increased use in practice. This study aims to advance stormwater management practice and research by presenting a detailed case study of the development, implementation and evaluation of a targeted behaviour change trial that engaged small to medium industrial businesses in stormwater pollution prevention. Utilising a combination of different behaviour change strategies - including capacity building, social norms and commitment - a number of preventative stormwater pollution behaviours were changed in participating businesses. Our study provides a practice model for tackling stormwater pollution from a behavioural perspective that can be further developed by both practitioners and researchers to create effective and long-lasting change.

1. Introduction

Despite increased use of non-structural measures to manage stormwater pollution in industrial areas, there is still little high-quality information of their performance and outcomes, and little research has been conducted on the relative effectiveness of different approaches (Urbonas, 2000; Taylor and Wong, 2002; Taylor and Fletcher, 2007). This paper adds to the existing knowledge base by presenting a detailed case study of the development, implementation and evaluation of a targeted behaviour change trial that engaged small to medium industrial businesses in stormwater pollution prevention. Our behavioural focus is unique to existing research in the field and provides a potential prototype for tackling industrial related stormwater pollution issues.

In the following sections, we map out the research and practice field of stormwater pollution management, as well as this case study's theoretical underpinnings. We then describe the nature of the trial in detail, including its key features and business engagement approach. The preliminary behavioural and water quality outcomes are presented and we finish by considering stormwater pollution management and research implications.

1.1. Current practice and research in stormwater pollution management

Stormwater discharge and run-off are major contributors to the pollution and degradation of urban waterways (Ahlman et al., 2005; Francey et al., 2010; Walsh et al., 2012, 2016). A range of stormwater pollution Best Management Practices (BMPs) are implemented by water managers worldwide to either reduce the overall amount of discharge or to improve its water quality. These measures fall into *structural* (fixed physical facilities such as dry basins or filter strips) or *non-structural* (non-physical interventions such as regulation or education) categories (Taylor and Wong, 2002; Taylor et al., 2007). In practice, most water managers combine measures from both categories to best address stormwater pollution issues (Phillips et al., 2002; Parkinson, 2003; Ahlman et al., 2005; Taylor and Fletcher, 2007; Walsh et al., 2016).

Taylor and Fletcher (2007) identify five main non-structural BMP categories:

1. Town planning controls (e.g. requirements for low-impact development designs)
2. Strategic planning and institutional controls (e.g. city-wide stormwater quality management plans)
3. Pollution prevention practices (e.g. street sweeping)
4. Education and participation programs (e.g. awareness raising and behaviour change campaigns)

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5. Regulatory controls (e.g. local laws that reduce erosion on building sites)

Non-structural BMPs are relatively inexpensive, flexible, and broadly applicable interventions for effective stormwater management, and are increasingly being used in practice (Taylor and Fletcher, 2007). Parkinson (2003) notes their particular potential in developing nations where resources might be scarce yet where the problems of flooding and environmental pollution often have a compounding impact on communities. Despite these advantages considerably less research attention has been given to non-structural measures when compared to structural ones (see for e.g. Barrett, 2005; Deletic and Fletcher, 2006; Roy et al., 2008; Davis et al., 2010; Hamel et al., 2013; Chaffin et al., 2016). Comparatively little is known about the relative effectiveness of different non-structural measures, the key factors influencing their performance and their impact on environmental quality (Urbonas, 2000; Chapman and Isensee, 2006; Taylor et al., 2007). Taylor and Fletcher (2007) argue that the use of non-structural BMPs "has been significantly hindered by uncertainty with respect to their performance … and how this varies over time, as well as their life-cycle costs" (p. 664).) While a number of different evaluation and monitoring approaches have been utilized to better monitor the performance of these BMPs, they were often poorly designed and applied (Taylor et al., 2007).

The peer-reviewed literature has a relatively limited number of non-structural BMPs examples that attempt to influence the awareness, knowledge and behaviours of specific audiences. Relevant studies have focused on identifying public perceptions of stormwater management issues (Giacalone et al., 2010; Typhina and Yan, 2014), on engaging households in stormwater sensitive lawn-care (Dietz et al., 2004; Eisenhauer et al., 2016), and in rainwater tank installation to reduce run-off (Brown et al., 2016). Outcome measurements from these studies were typically audience participation measures, while Dietz et al. (2004) measured self-reported behaviour change by the target audience, as well as changes in stormwater quality.

Research on non-structural BMPs that specifically target businesses is also under-represented in the literature. Shelton et al. (2015) developed an extension program that engaged green professionals and Master Gardeners in stormwater management principles and primarily measuring audience participation outcomes. Of most relevance to this study was Taylor et al.'s (2007) educational campaign that targeted local merchants and the general public within a small commercial precinct to reduce litter in stormwater. Multiple indicators (including behaviour and water quality change) were utilized to identify the campaign's overall impact. While innovative in its focus on businesses and its use of a broad evaluation framework, Taylor et al. (2007) report that their work was only modestly successful in influencing business and individuals' behaviours and in reducing actual litter loads in stormwater.

As a general rule, on-the-ground practice leads research in engaging the business sector in stormwater pollution, with a much larger number of case studies available through the non-peer reviewed literature (see for e.g.; Phillips et al., 2002; Waterwatch, 2002; DEC, 2004; AECOM, 2012; and EPA (NSW), 2016). While showcasing a range of approaches to engage different business types in different locations, program impact measures are typically limited to output (resources produced, events held, etc.) and target audience participation measures.

With these features of the evidence base in mind, this case study aims to present a theoretically supported behaviour change intervention to a small but important literature; demonstrate a monitoring and evaluation framework suitable for deriving conclusions about the effectiveness of the intervention; and, build the evidence base of non-structural stormwater BMPs utilized in industrial areas.

1.2. Theoretical underpinnings

The design and implementation of this trial intervention drew on the broader literature of environmental regulation compliance. While traditional measures emphasize monitoring and sanctions against non-compliers to maximize compliance (with the centralization of enforcement responsibilities within regulatory organisations), this 'command and control' approach is being challenged by the view that influencers such as social motivation, awareness and capacity can also effect compliance (Burby and Paterson, 1993; Winter and May 2001; May 2005; Murphy et al., 2009). A 'cooperative' or 'voluntary' approach is increasingly advocated to facilitate target groups' compliance with regulation through incentives, positive reinforcement, and other non-punitive means (Burby and Paterson, 1993; Segerson, 2013).

While there is empirical evidence that monitoring and enforcement does motivate compliance in certain groups (Gray and Shimshack, 2011), the literature cautions against over-generalising results from one sector to another, as a successful approach with one group may not work for another (May, 2005). Different stakeholders have markedly different understanding of particular issues (such as stormwater pollution) and what is required of them by way of response, and varying levels of capacity to change their current behaviours. Therefore, multiple ways of ensuring compliance are required (Winz and Brierley, 2009; Kaplowitz and Lupi, 2012).

The voluntary approach to regulation compliance is consistent with a view of behaviour that recognises the individual and social motivations of actors - along with their capacity and commitment to act - as influential conditions for regulation compliance. Burby and Paterson (1993) adopt this view in noting regulatory strategies that emphasize "capacity building and the social and moral bases of compliance *in addition* to deterrence and the threatened application of sanctions" (p.753, italics added).

As detailed below, this trial intervention draws on the voluntary approach as a theoretical framework to encourage business compliance with stormwater pollution requirements. We utilize a combination of different behaviour change strategies focusing on capacity building, social norms and behavioural commitment – in addition to the backstop of potential monitoring and enforcement from the state-based environmental regulator.

1.3. The nature of the trial – target audience, target behaviours and intervention components

This section includes descriptions of: i) the study site, ii) the target business groups, iii) the relevant stormwater pollution management behaviours and, iv) the key components of the intervention.

The research team partnered with the metropolitan water authority, the state-based Environmental Protection Authority (EPA) and the local council, to co-design, deliver and evaluate the outcomes of the intervention. Each group had carriage for particular elements, with the researchers being responsible for the design of the overall intervention, as well as training and supporting the onsite assessors (see below), developing the monitoring and development framework, and analyzing behaviour change outcomes (see Method). Prior to the design of the trial, the research team conducted a literature and practice review of national and international stormwater management and environmental regulation, as well as a series of interviews with key local stakeholders (see Jorgensen et al., 2015). This data informed the design and