Research article

Survey of the effect of odour impact on communities

J.E. Hayes [a, *], R.J. Stevenson [b], R.M. Stuetz [a]

[a] UNSW Water Research Centre, School of Civil and Environmental Engineering, University of New South Wales, Sydney, 2052, Australia
[b] Department of Psychology, Faculty of Human Sciences, Macquarie University, Sydney, 2109, Australia

ABSTRACT

In the context of environmental malodour, surveys are valuable as they allow for the relatively detailed analysis of multiple factors pertaining to odour perception and subsequent reaction. However, the causes for an individual to experience odour impact while a neighbour will not are still not understood. The goal of this current survey design was to consolidate varying research paths for surveys within the environmental odour research space. This survey investigated the area of effect for wastewater treatment plants by using stratified random sampling techniques that radiated from the industrial areas. Additionally, this survey provided a "non-alerted" response to environmental malodour that represents a step forward for ecological validity. We found a small number of items relating to odour annoyance and home ownership that can be used in order to predict odour impact for individual community members. However, we also did not find any relationship with odour impact and perceived control. This survey design and analysis reconciles the varied approaches towards community surveys administered in prior literature, as well as providing information to improve future community engagement policies.

© 2017 Elsevier Ltd. All rights reserved.

1. Introduction

A core component of research on the effect of malodours on communities has centred around the use of survey questionnaires for a way by which to provide a standardised evaluation (Johnson and Sobel, 2007; Hayes et al., 2014). Recently, surveys have looked at three primary factors with relation to environmental odour, this has included the effects of health and wellbeing, using members of the community to report on odour impact, and the way in which perception affects odour impact (Steinheider and Winneke, 1993, Cavalini, 1994; Schiffman et al., 1995; Dalton, 1996; Sakawi et al., 2011). Odour assessments made by members of the community can include them as field observers supplied with material to effectively log odour events; comparatively, studies investigating the qualities of perception involve investigating the factors involved in modulating odour perception such as the hedonic qualities of the odour (Dalton et al., 1997; Sucker et al., 2004; Sakawi et al., 2011).To meet these goals, varying methodologies have been developed, increasing in both specificity and complexity, which in turn has gleaned intriguing relationships between community and environmental odour exposure. With

regards to health and wellbeing, health issues appear to manifest within odour-affected communities, although the underlying mechanism and detail are not yet clear - although factors such as perceived control (a measure of a person's ability to attain desired goals and avoid negative outcomes) have been suggested (Shusterman, 2001; Bullers, 2005; Schiffman and Williams, 2005). Perception as a modulating factor has also been heavily researched, and it appears that negative perceptions of odours tend to result in increased odour annoyance and intensity, as well as more drastic health complaints (Dalton, 1996; Distel et al., 1999; Elliott et al., 1999; Ferdenzi et al., 2011; Kärnekull et al., 2011). Research into both health effects and perception has suffered from a lack of unified measurement strategies. Investigations have rarely replicated tools from prior research, which may be a partial explanation for a lack of consensus. The appreciation of community odour exposure is comparatively better established, thanks in part to national standards such as the European VDI 3883 (Evans and Tafalla, 1987; Winneke, 2004; Winneke et al., 2004). These standards may differ, but they all focus on a handful of odour qualities such as annoyance, frequency, duration, and location, and as a result provide relatively comparable information (Cavalini, 1994; Both et al., 2004; Sironi et al., 2010).

What current research has not focused on is the way in which varying factors relating to odour exposure, such as the attitude of the odour-producing industry, is related to complaints and action

---

* Corresponding author.
E-mail address: j.e.hayes@unsw.edu.au (J.E. Hayes).

against authority, as well as the ways in which individuals attempt to modify their environment in relation to odours (Jonsson, 1974). This research is crucial for industry as a means to anticipate and ameliorate community dissatisfaction and complaint. While prior research has alluded to the likely reactions undertaken by dissatisfied community members, there has not as yet been a study that has attempted to identify what distinguishes a person who is likely to register a complaint, versus one who does not (Cavalini et al., 1991). Similarly, little is understood regarding the type of actions likely to be taken by a dissatisfied community member; for instance, research cannot inform which community members tend to escalate complaints, or if they use a complaint system to provide odour observations with no intention of escalation.

This study elucidates the relationships between wellbeing, odour annoyance, demographics, and endeavours to identify which of these factors predispose a community member to experience odour impact. Moreover, within odour-affected individuals, we hope to establish a relationship between odour exposure qualities, and the types of complaints and behaviours an odour-affected community member is likely to exhibit.

2. Materials and methods

Our areas of investigation centred on three sites in a major metropolitan city on the Eastern Coast of Australia: a Wastewater Treatment Plant (WWTP) (Site 1) with a history of a high number of complaints received by the community (200 + within the time period 2004–2014), a WWTP (Site 2) with a history of low number of complaints (2 within the time period 2004–2014), and a control site (Site 3) with no nearby WWTP or other industry. The control site was selected on several criteria: it shared comparable scores for its Socio-Economic Indexes for Areas (SEIFA) compared to the WWTP sites, it possessed a similar landscape (i.e. close to the coastline), and it was within the same city limits (Australian Bureau of Statistics, 2013).

The survey itself consisted of 31 items designed based on prior literature, and related to factors previously explored (see Supplemental Fig. 1). These factors included questions pertaining to health, perceived control, depression, the perception of odour impact, hedonic and attitudinal appraisal of industry types (water treatment, manufacturing, and so on), as well as questions relating to demographics. The survey questions and design were based upon a number of prior investigations (Holmes and Rahe, 1967, Jonsson, 1974; Pearlin and Schooler, 1978, Devins and Orme, 1985, Watson and Pennebaker, 1989, Neutra et al., 1991; Dalton and Dilks, 1997; Sucker et al., 2004; Bullers, 2005; Papo et al., 2006; Wing et al., 2008; Kärnekull et al., 2011). Of note, we used Pearlin and Schooler's short form of environment mastery to establish perceived control and the CES-D depression scale to evaluate depression. In order to establish a "non-alerted" response, we avoided mentioning any specific odour-causing locale, and the survey did not prompt for odour-related health and wellbeing responses (Robinson et al., 2012).

Survey analysis was established by establishing factors relating to odour impact. The characteristic whether an individual was affected by odour impact was determined through the item "Are there noticeably bad smells and odours in your community that *impact you in some way*?". Significant relationships with this item to other items/factors were established by chi square, or where appropriate, ANOVA. All analysis was conducted using SPSS 18. Items that were significantly related to odour impact were compiled into a binary logistic regression group. Of those individuals who did report environmental impacts, cluster analysis was used to identify the relationships between behavioural changes, attitudes, and likely actions regarding environmental

malodour.

Surveys were distributed via post and hand delivery in a stratified random sampling technique (Fig. 1). To avoid confounds over odour sources as well as to simplify analysis, industrial (of which there was none) and commercial areas were excluded from the survey distribution. These areas were excluded based on their zoning designation provided by local council. In order to establish the limits of the effects of the WWTPs surveyed, the surrounding communities were surveyed to a radius of 3 km from the WWTP (or in the case of the control, the coastline). This was indicated by the respective plants' complaint history in that complaints extended to only a 2 km range; it was desirable to establish the maximum distance that the WWTP could perceive to cause odour impact. The circumference of each marked kilometre radius from the WWTP was divided into eight equally-sized zones that encompassed residential areas (Fig. 1). This equated to a total of 24 zones per survey area. Each of these zones were given 30 randomly distributed surveys, 720 in total. Some slight alterations were made for Site's 1 and 2. A poor response rate to the original survey at Site 1 necessitated a second round of distribution, in this instance 10 surveys per zone (240 in total). These new round of surveys, as well as those delivered to Site 2 and 3, included a prize draw incentivization (de Vaus, 2002). In addition, some of Site 2's residential areas were exhausted with regards to sufficient dwellings, reducing the number of delivered surveys to 625.

This study was approved by the UNSW Human Ethics Committee (approval number HC13261).

3. Results

Overall, most odour observations were predominantly attributed to the WWTPs. Other sources of complaints included garbage
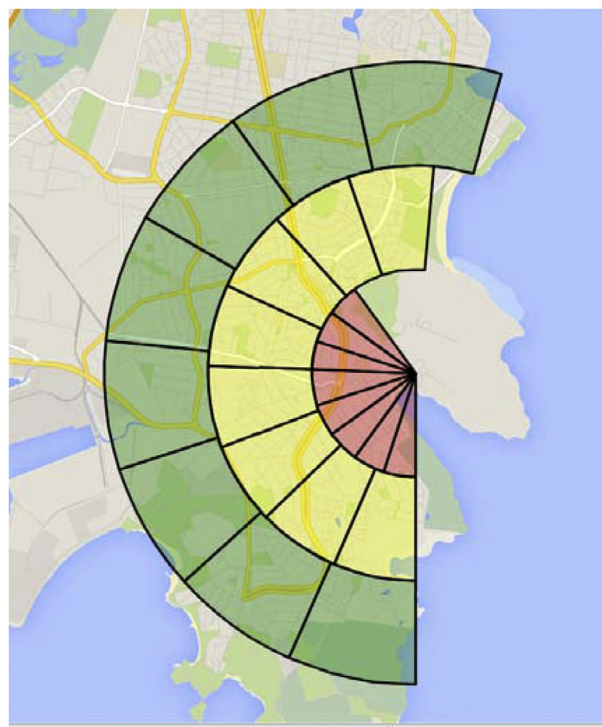
Fig. 1. Example of zoning distribution pattern. Each zone received 30 randomly distributed surveys. The red zones represent area within the 0−1 km radius from the WWTP, yellow for the 1−2 km radius, and green represents the 2−3 km radius. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)