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Finding clean water habitats in urban landscapes: professional researcher vs citizen science approaches

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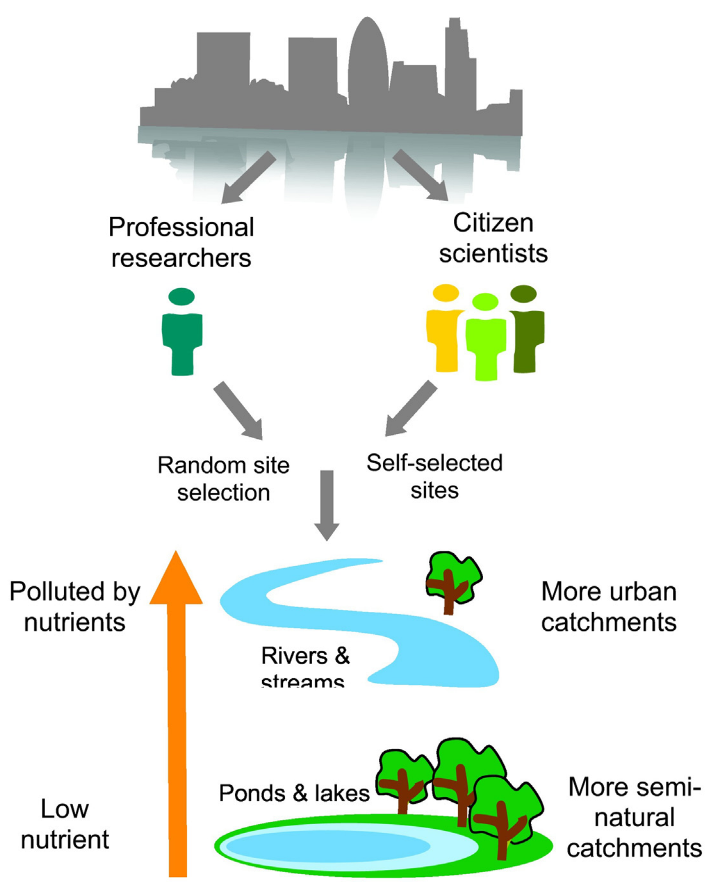
HIGHLIGHTS

- Citizens and ecologists collected nutrient data from waterbodies across London.
- Citizen sites were self-selected, the ecologists collected stratified random data.
- Both showed that ponds & lakes had fewest nutrients, rivers were far more polluted.
- However citizen nutrient data failed to show expected relationships with land cover.
- Citizen science data would be more valuable if survey locations were pre-selected.

GRAPHICAL ABSTRACT



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ABSTRACT

This study investigated patterns of nutrient pollution in waterbody types across Greater London. Nitrate and phosphate data were collected by both citizen scientists and professional ecologists and their results were compared. The professional survey comprised 495 randomly selected pond, lake, river, stream and ditch sites. Citizen science survey sites were self-selected and comprised 76 ponds, lakes, rivers and streams. At each site, nutrient concentrations were assessed using field chemistry kits to measure nitrate-N and phosphate-P.

The professional and the citizen science datasets both showed that standing waterbodies had significantly lower average nutrient concentrations than running waters. In the professional datasets 46% of ponds and lakes had nutrient levels below the threshold at which biological impairment is likely, whereas only 3% of running waters were unimpaired by nutrients. The citizen science dataset showed the same broad pattern, but there was a trend towards selection of higher quality waterbodies with 77% standing waters and 14% of rivers and streams unimpaired.

Waterbody nutrient levels in the professional dataset were broadly correlated with landuse intensity. Rivers and streams had a significantly higher proportion of urban and suburban land cover than other waterbody types. Ponds had higher percentage of semi-natural vegetation within their much smaller catchments. Relationships with land cover and water quality were less apparent in the citizen-collected dataset probably because the areas visited by citizens were less representative of the landscape as whole.

The results suggest that standing waterbodies, especially ponds, may represent an important clean water resource within urban areas. Small waterbodies, including ponds, small lakes < 50 ha and ditches, are rarely part of the statutory water quality monitoring programmes and are frequently overlooked. Citizen scientist data have the potential to partly fill this gap if they are co-ordinated to reduce bias in the type and location of the waterbodies selected.

1. Introduction

The process of urbanisation is an ongoing global phenomenon affecting both the developed and developing worlds. Current projections estimate that the extent of urban land cover worldwide will increase by 185% between 2000 and 2030 (Seto et al., 2012), with concomitant infill-development increasing building density and decreasing the remaining extent of urban green space (Gledhill et al., 2008).

Urbanisation has been shown to cause profound changes to the freshwater environment: rivers and streams are typically channelised or culverted whilst most standing waters are either destroyed or modified into amenity features (Booth and Jackson, 1997; Meyer and Wallace, 2001; Wood et al., 2003). Hydrological changes alter the availability of water including its volume, velocity and periodicity, which in turn impacts water chemistry, sediment loading and the character of bottom substrates (Boyer and Polasky, 2004). The run-off to waterbodies from urban surfaces can be polluted by a combination of elements including oils, metals, nutrients, pathogens and a wide range of man-made compounds: an issue which is compounded, particularly in running waters, by inputs of treated and untreated sewage, licensed and unlicensed industrial discharges and effluents that reach watercourses as a result of drainage system misconnections (Gerken Golay et al., 2013; Latimer and Quinn, 1998; Lenat and Crawford, 1994; Paul and Meyer, 2001; Sonoda et al., 2001). This plethora of physico-chemical changes inevitably impacts freshwater biodiversity and biological processes, with most studies suggesting that the net effect is strongly detrimental (Booth et al., 2004; Lenat and Crawford, 1994; Paul and Meyer, 2001, and references therein).

Given that the impacts of urbanisation on freshwaters are held to be wide-ranging and generally damaging, it is surprising that there are remarkably few empirical data describing the quality of freshwaters in urban areas. In rural landscapes, studies have shown considerable heterogeneity in the extent to which waterbodies degrade as a result of anthropogenic impacts. Small waterbodies like ponds, for example, have sometimes been shown to retain relatively clean water and high biodiversity even in intensively managed agricultural catchments, enabling them to contribute disproportionately to regional biodiversity (Williams et al., 2004; Davies et al., 2008b; Biggs et al., 2016a, 2016b). There are no equivalent studies that compare waterbody types in urban environments, despite the multiple ecosystem services urban freshwaters provide including flood amelioration, water treatment, delivery of potable water, protection of biodiversity, creation of amenity resources and provision of green space with its inherent value for promoting emotional and physical health (Hassall, 2014 and references therein; Hassall and Anderson, 2015; Völker and Kistemann, 2015; Bradley and Frost, in this issue). Increasing our understanding of the value of the urban freshwater resource has the potential to enable us to better balance and protect these uses.

In Europe, the ecological quality of freshwaters is monitored under the auspices of the EU Water Framework Directive (2000/60/EC) which requires member states to maintain the quality of all fresh waters across their territory. In practice, only a tiny proportion of the freshwater network is assessed in any EU State and, statutory monitoring for the Directive has a strong bias towards larger waters: focusing on rivers and lakes over 50 ha. This means that small streams, headwaters, ditches, ponds and most lakes are almost entirely overlooked both in terms of monitoring, and action to protect their quality.

A possible solution to the paucity of information about the quality of urban freshwaters would be to augment professional water quality monitoring data with citizen science-collected data. Citizen-collected data are already essential for many disciplines involving the collection of large-scale field datasets, and are beginning to be used for freshwaters particularly for assessing the river quality in order to pick-up pollution events (Canfield et al., 2002; Loperfido et al., 2010; Obrecht et al., 1998; Rotman et al., 2012). Such an approach has the added benefit of directly involving communities in activities to protect their local environment, and is particularly feasible for urban areas because of the large audience of potential volunteers (Canfield et al., 2002).

In the current study our aims were twofold:

(i) to evaluate for the first time the patterns of water quality, evident across all fresh waterbody types within catchments of differing levels of urbanisation in a major city, Greater London, using data collected by professional cologists
(ii) to establish whether citizen science-collected data has the potential to adequately replicate the patterns evident in a professionally collected research dataset.

To assess water quality we focused on two widespread pollutants: phosphate and nitrate. These nutrients are amongst the most pervasive