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Influence of uncertainty inherent to heavy metal build-up and wash-off on stormwater quality

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ABSTRACT

Uncertainty inherent to heavy metal build-up and wash-off stems from process variability. This results in inaccurate interpretation of stormwater quality model predictions. The research study has characterised the variability in heavy metal build-up and wash-off processes based on the temporal variations in particle-bound heavy metals commonly found on urban roads. The study outcomes found that the distribution of Al, Cr, Mn, Fe, Ni, Cu, Zn, Cd and Pb were consistent over particle size fractions <150 μm and >150 μm, with most metals concentrated in the particle size fraction <150 μm. When build-up and wash-off are considered as independent processes, the temporal variations in these processes in relation to the heavy metals load are consistent with variations in the particulate load. However, the temporal variations in the load in build-up and wash-off of heavy metals and particulates are not consistent for consecutive build-up and wash-off events that occur on a continuous timeline. These inconsistencies are attributed to interactions between heavy metals and particulates <150 μm and >150 μm, which are influenced by particle characteristics such as organic matter content. The behavioural variability of particles determines the variations in the heavy metals load entrained in stormwater runoff. Accordingly, the variability in build-up and wash-off of particle-bound pollutants needs to be characterised in the description of pollutant attachment to particulates in stormwater quality modelling. This will ensure the accounting of process uncertainty, and thereby enhancing the interpretation of the outcomes derived from modelling studies.

1. Introduction

Heavy metals are common stormwater pollutants found in urban environments. The presence of different heavy metal species is attributed to specific sources, particularly automobile–use activities and industrial activities (Councell et al., 2004; Gunawardena et al., 2013; Mummullage et al., 2014). During dry weather periods, heavy metals build-up on urban impervious surfaces (e.g. roads, parking lots), and are subsequently washed-off during storms events. Stormwater runoff, which may carry significant amounts of heavy metals, is thus identified as a major non-point source of pollution to urban water bodies (Al Bakri et al., 2008).

The toxicity and the bioavailability of heavy metals discharged to urban waters exert significant impacts on ecosystem health (Beasley and Kneale, 2002; Islam et al., 2015). Consequently, urban water management recognises the importance of the mitigation of heavy metal pollution of stormwater as essential for safeguarding the urban aquatic environment (Barbosa et al., 2012; Niemczynowicz, 1999). However, the effectiveness of treatment strategies for removing specific pollutants such as heavy metals can be unreliable. This is due to decision making in relation to stormwater pollution mitigation relying on incomplete knowledge about the processes which these pollutants undergo (Li et al., 2006; Revitt et al., 2014; Stagge et al., 2012). In this context, the intrinsic variability of pollutant build-up and wash-off processes is one of the least investigated attributes of pollutant processes. This process variability creates uncertainty in relation to these processes. The process uncertainty constrains the accurate interpretation of stormwater quality predictions, which is the basis for management decision making (Haddad et al., 2013; Lee et al., 2012; Sun et al., 2012; Zoppou, 2001). Therefore, poor assessment of process uncertainty may significantly impact on the effectiveness of any stormwater pollution mitigation strategies implemented.

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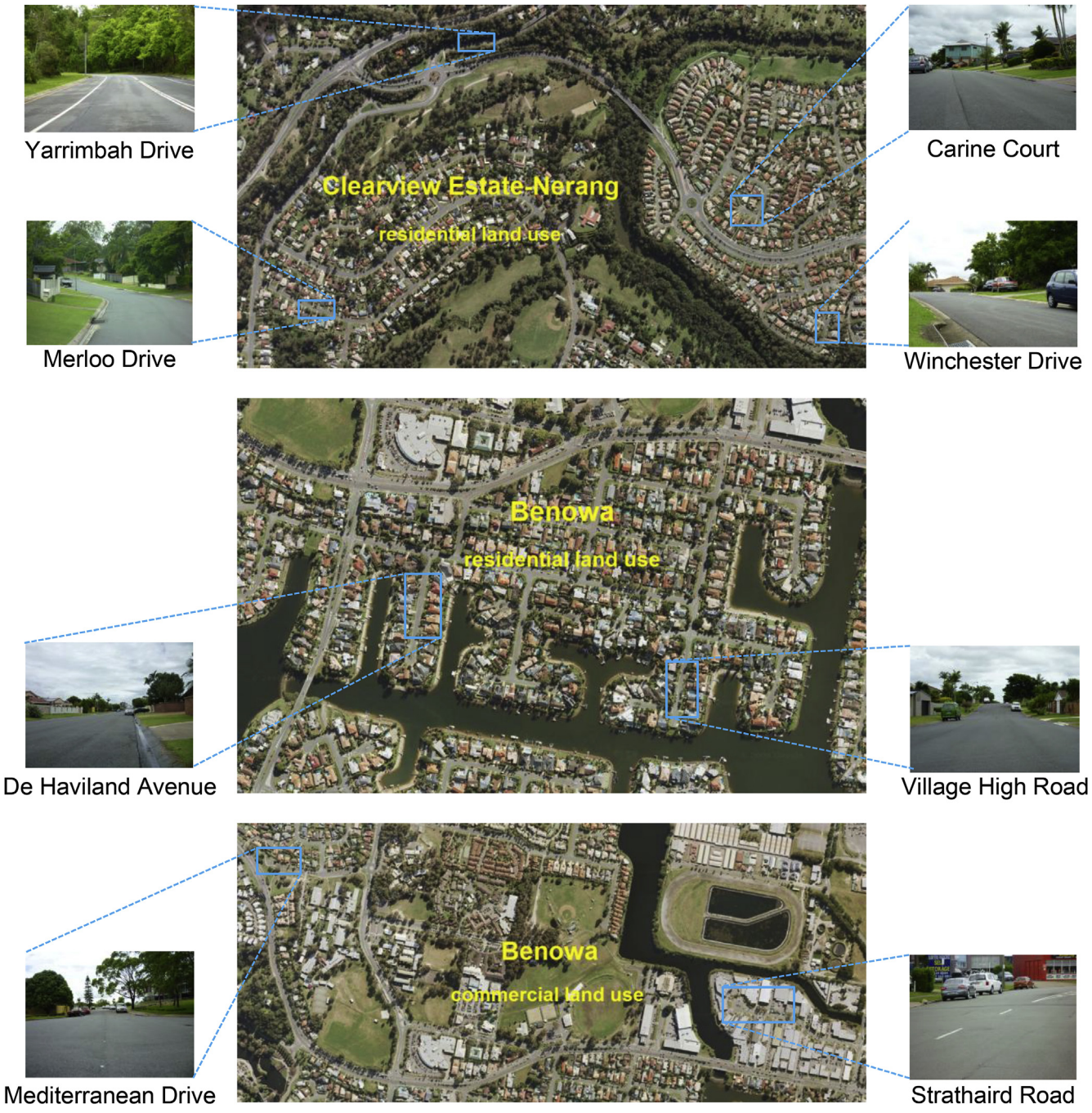

Fig. 1. Aerial and street views of the road study sites.

Table 1
Characteristics of the road study sites.

Suburb	Urban form			Road surface condition
	Housing type	Household density (households/km^2)[a]	Population density (residents/km^2)[a]	
Clearview Estate-Nerang	Detached housing	402.6	456.6	Asphalt paved Good condition Fair slope
Benowa	Detached and town housing, waterfront properties, warehouses, workshops	167.1	1173.4	Asphalt paved Poor condition Mild slope

[a] ABS (2011).