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Role of particle size and composition in metal adsorption by solids deposited on urban road surfaces

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ABSTRACT

Despite common knowledge that the metal content adsorbed by fine particles is relatively higher compared to coarser particles, the reasons for this phenomenon have gained little research attention. The research study discussed in the paper investigated the variations in metal content for different particle sizes of solids associated with pollutant build-up on urban road surfaces. Data analysis confirmed that parameters favourable for metal adsorption to solids such as specific surface area, organic carbon content, effective cation exchange capacity and clay forming minerals content decrease with the increase in particle size. Furthermore, the mineralogical composition of solids was found to be the governing factor influencing the specific surface area and effective cation exchange capacity. There is high quartz content in particles >150 μm compared to particles <150 μm. As particle size reduces below 150 μm, the clay forming minerals content increases, providing favourable physical and chemical properties that influence adsorption.

1. Introduction

Build-up solids on urban road surfaces are a sink for potentially toxic pollutants such as metals generated by various anthropogenic activities common to the urban environment (Rogge et al., 1993; Goonetilleke et al., 2009). The significance of these pollutants on the health of receiving water bodies depends on the bioavailable fraction attached to solids which are available for wash-off by stormwater runoff (Sutherland and Tolosa, 2000). Therefore, in order to develop effective stormwater quality mitigation strategies, an in-depth understanding of the factors that influence metal adsorption to solids and the nature of the adsorption processes is essential.

Despite the common understanding that a comparatively high metal load is present in fine particles in pollutant build-up compared to coarser particles, there is paucity of scientific knowledge regarding the reasons for this behaviour (Sansalone and Kim, 2008). Research literature commonly states that the surface characteristics of solids influenced by their composition play a significant role in the adsorption and desorption processes of metals from a particle surface (Bradl, 2004; Gunawardana et al., 2013).

Considerable knowledge has been developed regarding the characteristics of individual substances common to build-up on road surfaces such as organic matter (Greenland and Hayes, 1981; Rogge et al., 1993), minerals (Roger et al., 1998), soil and tyre wear particles (Adachi and Tainosho, 2004). Previous research studies have confirmed that road deposited solids contain a mix of these pollutants (Gunawardana et al., 2012a; Kreider et al., 2010). It is hypothesised that the diversity of physical and chemical properties exhibited by these pollutants is influenced by their sources of origin. Consequently, an in-depth understanding of the physical and chemical parameters of solids particles and their sources of origin are vital in order to assess the potential contribution of toxic pollutants adsorbed to road deposited solids particles.

The primary objective of the research study discussed in this paper was to identify the important factors which influence metal adsorption to different particle sizes of build-up solids. Accordingly, solids samples deposited on urban road surfaces with diverse mineralogy and anthropogenic origin were analysed for a range of key physical and chemical properties. The research study outcomes are expected to contribute to a greater understanding of the role of solids characteristics in metal adsorption and thereby to contribute to enhancing stormwater management practices which commonly target solids removal for stormwater quality improvement.

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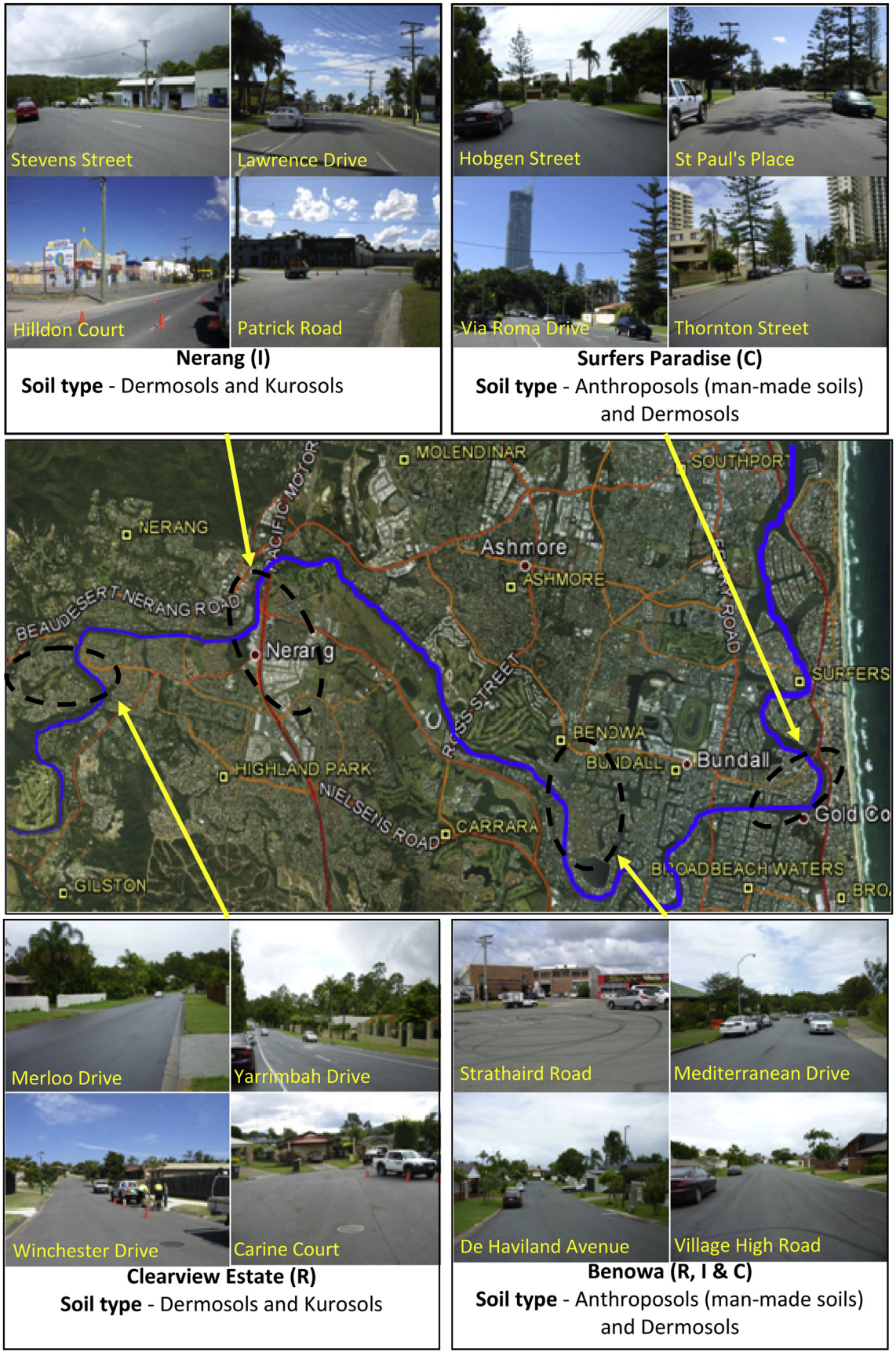

Fig. 1. Locations of study sites. Note: R – residential, C – commercial, I – industrial.