

Lead and zinc removal with storage period in porous asphalt pavement

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ABSTRACT

Porous asphalt pavements have been used as an effective technique to overcome road runoff challenges, and to improve efficiency of rainwater utilisation in urban areas. Using porous asphalt pavements with reservoir storage and harvesting facilities is an important consideration for the future. This study monitored changes in water quality indicators, such as pH, conductivity, and concentrations of lead and zinc, for water stored in porous asphalt pavement models with basalt-, limestone- and 'basalt+limestone'-filled reservoir structures. The research discusses findings over a 696-h storage period following artificial rainfall. Total lead and zinc concentrations were remarkably reduced throughout the initial flush, showing, on average, reductions of 90% and 80.5%, respectively. This pattern was consistent throughout the storage period, producing average reductions in lead and zinc of 99.98% and 79%, respectively, over 696 h. Conductivity and pH levels increased in all pavement models after the 696-h storage. The results obtained confirmed the potential of using porous asphalt pavements with reservoir structures to remove heavy metals from road runoff. This can be applied to future research on the removal mechanisms of porous asphalt pavements in relation to heavy metals in road runoff.

Keywords: heavy metals, road runoff, porous asphalt pavement, retention

INTRODUCTION

Urbanisation has resulted in a rapid growth of impermeable surfaces over the past decades, such as roofs, squares, car parks and roads. Due to the decreasing space available for water penetration, this change has significantly influenced the hydrologic characteristics of stormwater runoff, by increasing runoff peak flow rates and peak velocities, and decreasing lag time and water quality (Field et al., 1982). Over time, several principal problems have emerged, including city flooding, lowering groundwater levels, and surface water pollution.

Large amounts of pollutants, including sediment (e.g., total suspended sediments (TSS)), nutrients (e.g., total Kjeldahl nitrogen (TKN)), oil and toxic chemicals from automobiles (e.g., total petroleum hydrocarbons (TPHs)), and heavy metals (e.g., lead, copper and zinc), are carried by stormwater runoff from impermeable surfaces during rainfall events (Singhal et al., 2008; Lee et al., 2011; Shinya et al., 2000; Helmreich et al., 2010), and are thus discharged into nearby water ecosystems without any treatment (Ukabiala Chinwe et al., 2010; Lee et al., 2011). Among many other pollutants, heavy metals are highly hazardous due to their toxicity, non-biodegradation, and mass accumulation (Zuo et al., 2012; Zhang et al., 2012; Singh et al., 2011; Nie et al., 2008; Fuerhacker et al., 2011). Heavy metal accumulation in receiving waters can have a significant impact on aquatic organisms by absorption and bioaccumulation, potentially contaminating the local marine ecosystem (Vardanyan et al., 2006). Once heavy metals enter the food chain, they may accumulate to dangerous levels and be harmful to human life and other organisms (Zhang et al., 2012; Ip et al., 2005). As a result, stormwater runoff from impermeable

pavements is often regarded as an important source of pollution, particularly as such pavement areas in urban spaces are said to occupy twice the land area occupied by buildings (Ferguson, 2005). With respect to the receiving water environment (Murakami et al., 2009), treatment to remove heavy metals from road runoff is of high importance, and applicable to many countries around the world, both for stormwater mitigation, and water harvesting and reuse potential.

Porous asphalt pavements have been successfully installed in many countries as an effective method to overcome road runoff challenges, with their innovative design boasting benefits above those of conventional asphalt pavements (Zhao et al., 2012). Designed with built-in networks of void spaces, water and air can pass through the surface, base course and reservoir structures, finally entering the receiving environment (Legret et al., 1999; Roseen et al., 2012; Ferguson, 2005). As a result of this design, porous asphalt pavements are not only of benefit to the physical hydrology, reducing runoff peak and peak velocities during rainfall events, but also a beneficial way to improve the water quality of runoff. Some field studies have shown that porous asphalt pavements can provide benefits such as the removal of heavy metals from road runoff, in the long term. Early in 1987, Hogland et al. reported water quality improvement performance of several porous asphalt sites receiving snowmelt over a 1-year period. They found that a reduction of zinc by 17% was achieved by the porous asphalt pavement. Legret et al. (1996) reported heavy metal ion adsorption for a porous asphalt pavement with reservoir structure in Rezé, France, during a 4-year survey that showed a reduction of lead and zinc by 79% and 67%, respectively. Similarly, Baladès et al. (1995) reported that, over a period of 3 years, a reduction of lead by 93% was obtained from 3 sites in Bordeaux, France. Briggs (2006) reported a reduction of zinc by 96% over 1 year from a porous asphalt site in Durham, New Hampshire; in addition, Roseen et al. (2012) reported zinc removal of 95%, also over 1 year.

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