Resilience and sustainable drainage: end-of-life

Résilience et gestion durable des eaux pluviales : fin de vie

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RÉSUMÉ

Les SuDS (Systèmes de drainage durable, traduit de l'anglais Sustainable drainage systems) gèrent les risques environnementaux d'un ruissellement urbain et encouragent autant que possible les améliorations environnementales. Les SuDS sont efficaces pour piéger les polluants en accumulant le trop plein de sédiments et en améliorant les conditions dans le traitement de l'eau (par exemple les géotextiles dans les structures de pavés perméables). Cependant, les recherches à long-terme effectuées jusqu'à aujourd'hui sur le suivi et le sort des SuDS en fin de vie sont rares. Il demeure encore inconnu de savoir si les polluants sont capables d'atteindre le milieu récepteur si le seuil maximum de capacité des SuDS est atteint, et détériore alors la qualité de l'eau des trajectoires de l'eau locale. La fin de vie est définie comme l'expiration d'un appareil SuDS, pour laquelle l'efficacité de traitement des polluants a décliné. Etant donné que certains polluants sont non-dégradables, l'accumulation de contaminants pourrait être classée comme déchet dangereux en fin de vie, ce qui représente potentiellement un risque pour la santé de l'homme. Il est donc proposé de les évaluer dans leur biodisponibilité. De plus, l'accumulation de polluants non dégradables pourrait impacter la population microbienne dans les SuDS et affecter le processus de biodégradation dans ces systèmes. Ceci est une recherche exhaustive sur les conséquences du stockage de polluants dans les SuDS, leurs effets sur la fin de vie et la classification de l'accumulation de déchets.

ABSTRACT

SuDS (Sustainable drainage systems) manage the environmental risks of urban runoff and encourage environmental enhancement where possible. SuDS are efficient at trapping pollutants by accumulating sediment run-off and promoting conditions for water treatment (e.g. geotextiles in porous paving systems). However, previous research on the long term monitoring and fate of SuDS at their end-of-life is scarce. It is not known whether contaminants are capable of reaching receiving water bodies if the threshold of the SuDS capacity to hold pollutants is exceeded and thus, deterioring the water quality of local water courses. End-of-life is defined as the expiration of a SuDS device, where the efficiency to treat pollutants has declined. As certain pollutants are non-degradable, the build up of contaminants could possibly be classified as hazardous waste at end-of-life and a potential risk to human health. It is therefore proposed to assess them for their bioavailability. Additionally, the accumulation of non-degradable contaminants could impact the microbial community in SuDS and affect the biodegradation process in these systems. This is a comprehensive study on the consequences of pollutant storage in SUDs, the effects it has on end-of-life and the classification of the accumulated waste products.

KEYWORDS

SuDS, end-of-life, metals, microbial activity, bioavailability

1. INTRODUCTION

Urbanisation and the use of impervious surfaces have increased the levels of storm-water pollutants (Paul and Meyer, 2001). The Water Framework Directive (WFD 2000/06/EC) was established to improve water policy for the protection of all water bodies. As a result, Sustainable Drainage Systems (SuDS) or Best Management Practices (BMPs) have been recognised as one of the best methods for water quality control in urban runoff (Scholes *et al*., 2008). Pollutants in SuDs are trapped in the device and accumulate over time. The definition of end-of- life, for this study, is established as the expiration of a SuDS device, where the efficiency to treat pollutants has declined. Scenarios for the removal of SuDS at end-of-life do not exist for the majority of SuDs devices and it is uncertain whether the contaminants accumulated in these devices would be classified as hazardous waste.

Currently, research on the external costs and decommissioning or replacement of SuDS at end-of-life is minimal (Flynn and Traver, 2013). Solutions for remediating contaminated land is moving away from the traditional 'dig and dump' method and there is an increasing use of treatment and innovative reuse methods for disposal (Baylis and Allenby 2010). Therefore, this study could provide significant information on the procedures and costs for disposal.

1.1. Contaminants and end-of-life

Pollutants can be identified in different forms in SuDS systems, such as, dissolved, colloidal or associated with particles (Eriksson *et al*., 2007). Higher pollutant concentrations have been associated with finer sediment fractions (Horowitz 1991). Sorption of heavy metals has been considered the most effective wastewater treatment method and is one of the main advantages of SuDS (Zhao *et al*. 2011).

Metals are non-degradable and long-term deposition can cause metal contamination of surface soils (Tsavdaris *et al*., 2013). Metals associated with road runoff are from tyre and brake lining wear, corrosion of metal and combustion of lubricating oils from vehicles (Makepeace *et al*., 1995). The accumulation of metals in SuDS sediments are a concern for the biological functioning and long term treatment efficiencies of the system. Non-degradable contaminants will be retained in SuDS until the device is excavated for maintenance or disposal. If the sediment is not excavated, contaminants could potentially leach out into the recieving water course or the surrounding sediment.

The biodegradation of hydrocarbons through microbial acitivity has been demonstrated by previous studies (e.g. Pratt *et al*. 1999). Heavy metal concentrations can affect the composition of microbial communities. Metals essential for growth (e.g Cu and Zn) and metals with no known biological functioning (e.g. Cd and Pb) can accumulate to high concentrations and show signs of toxicity to the microbial community (Gadd, 1993). Chaudri *et al*. (2008) found a gradual zero in population size of the nitrogen fixing bacteria *Rhizobium leguminosarum* biovar *trifolii* as a result of increasing Zn concentrations. Metal accumulation could potentially impact on biodegradation processes and nutrient cycling in SuDS. If hydrocarbons are not degraded efficiently, the potential leachability of these contaminants could categorise the sediment as hazardous waste at end-of-life.

Previous studies have not defined the fate of SuDS at end-of-life and whether the contaminants are a risk to human health. Additionally, extensive research on the treatment efficiency of SuDS has not established the fate or behaviour of the contaminants once they are stored in the system. It is unknown whether SuDS become 'full' of contaminants as a result of long term pollutant loading and, therefore, negatively impact on the recieving water body. Additionally, it is unknown whether metals in SuDS are bioavailable, and therefore, a risk to human health. This study will be using a combination of field studies and laboratory simulations to determine the expiration of a SuDS device. This research will evaluate the sustainability of SuDS and what happens to these systems at end-of-life.

2. METHODS

The aim of the study is to identify an end-of-life scenario where the water quality of the outflow from SuDS has deteriorated as a result of heavy metal pollutant loading. The study will primarily focus on metals (both total and available concentrations) and the effect it has on the microbial community. Material from the two sites chosen for this research will be excavated and reconstructed in rigs designed for laboratory simulations. Both sites chosen for this study were installed before any guidance on the design or maintenance of SuDS had been released.

The Hopwood Motorway Service Area (HMSA) SuDS management trains are located in Worcestershire, UK and was installed in 1999. Heal *et al*. (2009) compiled extensive research on the water and sediment quality of the four SuDS management trains at the HMSA. The retention of sediment and contaminants has been clearly demonstrated from the integrated studies. The second management train receives runoff from a fuel-filling station, access road and coach park. The discharge is pre-treated by an oil and silt interceptor before entering the management train which consists of a spillage basin, wetland, additional basin, shallow ditch and balancing pond. The spillage basin (Figure 1a) has been identified as a site of interest for this study as previous studies have shown contaminant concentrations exceeded water and sediment quality standards (Heal *et al*., 2009 ; Faram *et al*., 2007). Additionally, recent observations have shown an oil sheen on the surface water of the spillage basin after heavy rainfall events (Figure 1b). If the sediment previously trapped in the interceptor has been transported into the spillage basin since Faram *et al*.'s (2007) study, the water and sediment quality in the spillage basin may have deteriorated.

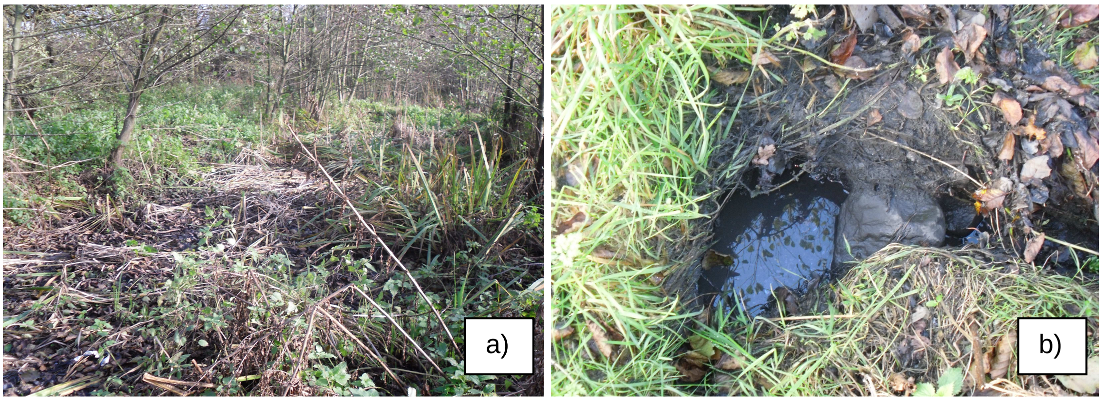

Figure 1. a) Spillage basin chosen for this study b) Outlet of the oil and silt interceptor into the spillage basin ('Pond 3') at the HMSA with a visible oil sheen.

The porous paving car park bay was located in Bury, UK (Figure 1a). The site was installed in 2003 and has recently been decommissioned. Underneath the interlocking porous paving blocks is the limestone aggregate, geotextile layer and permavoid structures (Figure 2b). The site was not maintained during its operation. Water quality analysis from the discharge of an adjacent asphalt car park bay found heavy metal concentrations were below drinking water quality standards. This suggests that the majority of contaminants are trapped on either the aggregate or geotextile layer in the car park bay. Fine grained sediment trapped by the geotextile layer can be seen in Figure 1b.

Figure 2. a) Interlocking porous paving car park bay excavated for this study from Bury. b) Excavation of the car park bay exposing the profile of a porous paving system.

3. FURTHER WORK

The permeable car park bay from Bury and the material from the spillage basin in the HMSA SUDS was reconstructed in three rigs where environmental conditions could be controlled and microbial activity could be measured regularly. Each rig has a different function : 1) the control 2) contaminated sediment additions (pollutants of known concentrations) 3) oil additions to establish a baseline for microbial activity. A rainfall regime replicating similar rainfall events from its original environment will be established using a rainfall simulator. Temperature and moisture content will be monitored throughout the study and kept at optimal conditions for microbial activity.

Extractable and total metal concentrations that will be assessed for this study (Cd, Cu, Cr, Ni, Pb, Zn, Fe, As, Mn). Sediment quality results will be used to determine the fate of contaminants trapped in SuDS and its potential disposal route. Additionally, the same metals will be analysed in the effluent of the rigs, after each rainfall event, to determine whether sediment loading has had a negative impact on the water quality. Throughout the study, pH, conductivity and TSS values will be measured as water quality parameters that can affect the behaviour of metals in the rigs. The final stages of the study will assess the bioavailability and leachability of contaminants through destructive sampling of the rigs.

Bacteria and fungi plate counts and microscopic counts of protists will determine the effectiveness of microbial degradation of oil pollutants. The rigs receiving contaminant additions will be monitored for changes in the species composition of the microbes and TPH concentrations to verify whether metal contamination has an effect on biodegradation of hydrocarbons. CO_2 concentrations and dissolved oxygen will be monitored as an indication of microbial respiration in the rigs. Furthermore, nutrients (N, P and K) are integral to sustaining a thriving microbial community. These parameters will be measured in the effluent of the rigs.

This study will establish what happens to SuDS end-of-life. Currently, research on SuDs end-of-life is limited and it is unknown whether the accumulated pollutants are classified as hazardous waste or harmful to human health. This poster shows the progress so far on this study and provides an insight into the possible issues that may arise from long term contaminant loading using an integrated field to laboratory study.

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