Managing hydrocarbons in the urban environment: implications for BMP selection

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Hydrocarbons are a ubiquitous contaminant of urban and highway stormwater flows, and the potential sources and pathways to the water environment are numerous. Many of these organic diffuse pollutants are toxic and can be difficult to break down in the environment. Polycyclic aromatic hydrocarbons (PAH's), for example, are priority hazardous substances targeted for control under the EU Water Framework Directive (WFD),and are implicated in stormwater toxicity.Numerous studies have reported negative impactsin streams receiving urban and highway stormwater flow, recording reduced populations and species diversity in impacted waterbodies demonstrating hydrocarbon contamination (e.g. Wilson et al, 2005; Maltby, 2005; Lafont, 2007).

Sustainable drainage systems, known variously as best management practices (BMPs) or sustainable urban drainage systems (SUDS), are now used routinely to protect surface waters from stormwater impact, both in terms of water quantity and quality. From a water quality perspective, performance of these systems is most often judged by pollutant removal efficiencies i.e. quantifying the reduction in pollutant concentrations and/or loads between inflow and outflow.More recently, rather than considering the removal of pollutants from the runoff in isolation, there has been a move towards a "whole-life" assessment of performance, BMPs being simply one component in an integrated water management regime. From this perspective, removal of contaminants from runoff is only part of the picture, as pollutants have not been removed from the environment, but instead redistributed to another compartment i.e.BMP soils and sediments (Bäckström et al, 2002).

Once retained in BMPs, hydrocarbons have the potential to degrade under suitable conditions, reducing residual contamination. Consequently, it makes sense to promote drainage infrastructure that not only attenuate pollutants, but also facilitates their degradation where possible, extending the lifetime of these structures, and improving their sustainability. Oxygen availability has been demonstrated as a limiting factor in the breakdown of hydrocarbons (e.g. Shin et al, 2000, Malinaand Zawierucha, 2007), suggesting that BMPs with exposed aerobic soils allow more degradation of organic pollutants than anoxic, submerged pond sediments. Evidence supporting this hypothesis gathered fromfield measurements and controlled studieshas been reported previously by the authors (Jefferies 2007; Napier et al 2009). Using previously unpublished PAH data from these studies, and evidence for contamination of urban drainage by hydrocarbons reported in the wider literature, this paper discussesto what extent selection of appropriate BMPs should be influenced by the degradability of hydrocarbons (specifically PAHs) within the treatment system. In particular, the paper discusses:

- Field data: data presented shows higher PAH concentrations accumulating in pond sediments than basin soils, and higher percentages of HMW PAHs persisting in pond sediments.

- Review of literature: ecotox studies report sediments, both in runoff and receiving waters, as being the source of elevated toxicity (e.g. Marsalek et al, 2002), with heavy molecular weight (HMW) PAH concentration identified as a major contributing factor (e.g. Lafont et al, 2007;Grapentine et al, 2008).
- Existing BMP guidance (in particular, the output of the pollutant-specific BMP selection tool developed by Revitt et al., (2008) is discussed).
- Maintenance issues: the literature reports concentrations of hydrocarbons in BMP sediments which frequently breach ecological guidelines while *in situ*(e.g. Weinstein et al, 2010), and preclude classification as inert waste, necessitating expensive disposal options once removed (e.g. Durand et al, 2004; Ellis and Rowlands, 2007).

BMP selection and optimisation advice is derived from the findings.

References

Bäckström, M., Malmqvist, P.A. and Viklander, M. (2002)Stormwater management in a catchbasin perspective – best practices or sustainable strategies? *Wat. Sci. Tech.***46** (6-7),159-166

Durand, C., Ruban, V., Ambles, A. and Oudot, J. (2004) Characterisation of the organic matter of sludge: determination of lipids, hydrocarbons and PAHs from road retention/infiltration ponds in France *Env. Poll.***132** 375-384

Ellis, J.B. and Rowlands, E.G. (2007) Highway filter drain waste arisings: a challenge for urban source control management? *Wat. Sci. Tech.***56**(10) 125-131

Grapentine L., Rochfort Q. and Marsalek, J. Assessing urban stormwater toxicity: methodology evolution from point source observations to longitudinal profiling *Wat. Sci. Tech.***57** (9) 1375-1381

Jefferies, C., Napier, F., Fogg, P. and Nicholson, F. (2008). Source Control Pollution in Sustainable Drainage, Final Report, Project UEUW01, SNIFFER, Edinburgh, Scotland.

Lafont M., Grapentine L., Rochfort Q., Marsalek, J., Tixier, G. and Breil, P. (2007) Bioassessment of wet-weather pollution impacts on fine sediments in urban waters by benthic indices and the sediment quality triad *Wat. Sci. Tech.***56**(9) 13-20

Malina, G. and Zawierucha, I. (2007) Potential of bioaugmentation and biostimulation for enhancing intrinsic biodegradation in oil-contaminated soil. *Bio-rem. Jour.***11** (3) 141-147.

Maltby, L., Boxall, A.B.A., Forrow, D.M., Calow, P. and Betton, C.I. (1995) The effect of motorway runoff on freshwater ecosystems: 2. Identifying major toxicants *Env. Tox Chem.***14** (6) 1093-1101

Marsalek, J. Rochfort Q., Grapentine L. and Brownlee, B. (2002) Assessment of stormwater impacts on an urban stream with a detention pond *Wat. Sci. Tech.***45** (3) 255-263

Napier, F., Jefferies, C., Heal, K.V., Fogg, P., D'Arcy, B.J. and Clark,e R.(2009) Evidence of traffic-related pollutant control in soil-based Sustainable Urban Drainage Systems (SUDS) *Wat. Sci. Tech.***60** (1) 221-230

Revitt,.DM., Scholes, L. and Ellis, J.B. (2008) A pollutant removal prediction tool for stormwater derived diffuse pollution *Wat. Sci. Tech.***57** (8) 1257-1264

Shin, W.S., Tate, P.T., Jackson, W.A. and Pardue, J.H. (2000) Bioremediation of an experimental oil spill in a salt marsh. Proceedings of Wetlands & Remediation: An International Conference. 33-40

Weinstein, J.E., Crawford, K.D. and Garner, T.R. (2010) Polycyclic aromatic hydrocarbon contamination in stormwater detention pond sediments in coastal South Carolina *Env. Mon. Ass.***162**21-35

Wilson, C., Clarke, R., D'Arcy, B.J., Heal, K.V. and Wrigh,t P.W. (2005) Persistent pollutants urban rivers sediment survey:implications for pollution control.*Wat. Sci. Tech.***51** (3-4) 217-224.