Can biofilters meet receiving water phosphorus targets? Apilot study using optimised metal oxide-rich filter media.

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Urban stormwater is a major contributor to the nutrient enrichment of waterways. Given the sensitivity of many local receiving waters to phosphorus concentrations, stormwater presents a serious challenge. Biofiltration has proven to be a successful technology for the treatment of urban stormwater, being easily integrated into streetscapes to provide flow attenuation and retention, pollution reduction and landscape amenity. Widespread implementation of biofilters has occurred across Australia over recent years and field monitoring of existing systems shows that biofilters are capable of meetingphosphorus *load reduction* targets. However, the concentration of total phosphorus in biofilter effluent still exceeds receivingwater quality guidelines(e.g. ANZECC & ARMCANZ 2000). Furthermore, biofilter lifespan remains of concern, being relatively short in comparison to more conventional water treatment options, and requiring significant maintenance. The timeframe over which continued phosphorus removal is assured is thus unknown. Optimisation of phosphorus removal is one of the most critical remaining knowledge gaps for biofiltration. Over several stages of experimental research, we aim to develop and test a biofiltration system, which addresses the problems surrounding optimisation of phosphorus removal.

Recently we undertook a pilot study to investigate thephosphorus sorption capacity of biofiltersfollowing the addition ofmetal oxide-rich media.This approach has previously proven successful in controllingphosphorusrelease from aquatic sediments usingvarious iron compounds (e.g. Murphy, Lawson et al. 2001; Smolders, Lamers et al. 2001).Thepilot study consisted of a series of compressed time, laboratory-scale experiments using through-flow sorption tests, which aimedto evaluate the improved capacity of a traditional biofiltration medium (loamy sand) to remove phosphorus from stormwater when augmented with various metal oxide-rich compounds. These included iron ore, goethiteand a naturally occurring red iron oxide sand (*Skye sand)*.

The pilot study was conducted using a 20L inflow tank, six threaded glass columns (Chromaflex, Multi-Lambda Scientific) of 25mm diameter and 150mm length and six peristaltic pumps. Each media configuration was replicated in triplicate, including a loamy sand only control. A synthetic solution containingdissolved phosphorus(KH_2PO_4) (0.1 mgP/L) and humic acid (3 mg/L), measured to typical Melbourne stormwater concentrations, was pumped through the columns over a 7 day period, operatingon 12 hour dosing intervals.During this period the equivalent of 2.5 years of rainfall-runoff (based on Melbourne average annual rainfall for a biofilter sized at 2% of its contributing impervious catchment), flowed through each column.Humic acid was included in the solution to account for the presence of organic matter or natural polymeric compounds in stormwater, which may compete with phosphorus for metal oxide binding sites (Hongve 1997). Influent and effluent samples were taken at the beginning of operation and then at intervals equivalent to six months of simulated rainfall until 2.5 years were completed. Samples were analysed for total phosphorus (TP), filterable reactive phosphorus (FRP), total organic carbon (TOC) and total iron (Fe). Upon completion of the experiment filter media cores from each column werepartitioned and analysed for FRP and Fe to determine potential correlations between iron and phosphorus in the media and implicate adsorption or precipitation interactions.Effluent water quality data were analysed to determine which media achieved the best phosphorus removal performance. The Skye sand-augmented medium showed the best performance of the media tested (Fig. 1.1). Effluent concentrations of TP from the Skye sandcolumns remained below standard Australian receiving water quality trigger values for lowland riversover the duration of the experiment. FRP remained below for the first 18 months simulated.

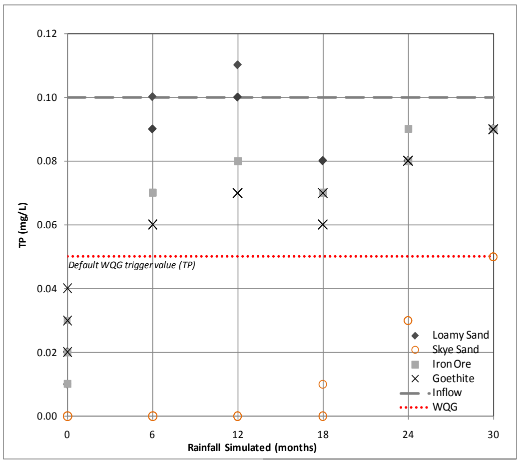

Figure 1.1 Effluent TP concentration(mg/L) over 2.5 years of simulated rainfall (FRP data, not presented, closely followed trends in TP)

While we observed that each of the augmented media had improved the phosphorus removal capacity of the loamy sand, the results suggested that iron content alone was not a good predictor of removal performance. Phosphorous interactions with other binding elements present in the compounds (e.g. Al, Ca, Mg) may also have influenced removal rates. Furthermore, we believe thatphysical characteristics(i.e. surface area, roughness and particle size distribution) may also play atleast as an important role as chemical composition in phosphorus removal. Addressing these questions will require further analysis of the media to ascertain whether differences in performance outcomes can be attributed tophysical structure.

These results suggest that the phosphorus removal capacity of biofilter media can be increased significantly through the addition of a silica-based, metal oxide-rich sand.This represents progress towards designing a phosphorus optimised biofilter, capable of meeting receiving water quality guidelines. However, the current trials have been conducted without vegetation and it is not yet known whether the augmented media will support plant growth. Additionally, the consequences of coupling an metal oxide-rich media and a saturated zone in a biofilter remains as yet unknown, as does the influence of such media on nitrogen removal. The next stage of research will address these remainingknowledge gaps through a large-scale vegetated biofilter column experiment. Once complete, design recommendations will beintegrated into the Australian stormwater biofiltration system adoption guidelines.Research and development of stormwater pollution control technologies, such as biofiltration systems,reflectsa continued commitment to protecting waterway health andintegratingwater sensitive urban design into Australian urban stormwater management.

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