

**INFLUENCE OF ENHANCED BIORETENTION
MEDIA AND TROPICAL SHRUB ON
NUTRIENT REMOVAL FOR URBAN RUNOFF
IN MIXED DEVELOPMENT AREA**

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UNIVERSITI SAINS MALAYSIA

2016

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TROPICAL SHRUB ON NUTRIENT REMOVAL
FOR URBAN RUNOFF IN MIXED DEVELOPMENT AREA**

by

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Thesis submitted in fulfilment of the requirements

for the degree of

Doctor of Philosophy

September 2016

ACKNOWLEDGMENT

First and foremost, I wish to express my deepest and most gracious gratitude to my main supervisor, Prof. Nor Azazi Zakaria, for the opportunity given to further my studies at the River Engineering and Urban Drainage Management Centre (REDAC) in USM Engineering Campus under the Academic Staff Training Scheme (ASTS) and funding by the Ministry of Higher Education Malaysia under the grant title of “Urban Water Cycle Processes, Management and Societal Interactions: Crossing from Crisis to Sustainability” with grant number as: 203/PKT/6720004. The invaluable advices, constructive suggestions and supportive resources had provided me an ideal environment for research.

Furthermore, I would like to express my sincere appreciation to Dr. Lau Tze Liang and Dr. Foo Keng Yuen, my co-supervisors for their undying dedication, in providing useful comments, remarks and engagement throughout the learning process and path towards the study. I really cherish the opportunity to work under their supervision. Not to forget Assoc. Prof. Ahmad Shukri Yahya from School of Civil Engineering, who has provided guidance, assistance and constructive feedback on statistical analysis.

In addition, I like to thank the entire office staff of REDAC, special thanks to Mr. Chang Chun Kiat and Mr. Leow Cheng Siang, whose interactions and opinions helped shaped this comprehensive research. Also, I would like to thank the entire technical support staff and research assistants of REDAC, especially Mr. Muhamad Shukry bin Mat Yusof, Mr. Muhammad Asri Abdul Azis and Mr. Khairul Azwan bin

Razali whose undivided attention and continuous assistance lead to the success of testing and data collection.

To my parents, Mr. Goh Pong Hing and Madam Cheng Chong Lang, my heartfelt thanks for their unfailing support, understanding and love without which the thesis would not have come to fruition. It has been a long journey throughout the study and I have both my ups and downs but I am indeed touched and grateful for the all the kind support, encouragement and assistance rendered by people around me one way or another. I will be forever grateful for all the love.

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LIST OF ABBREVIATION

Al	aluminium
ANOVA	analysis of variance
ASTM	American Society for Testing and Materials
Aus.	Australia
BAM	bio-sorption activated media
BMPs	Best Management Practices
BOD	biochemical oxygen demand
BOD ₅	five-day biochemical oxygen demand
C	carbon
Ca	calcium
Ca ²⁺	calcium ion
CaCO ₃	calcium carbonate
Ca ₅ (PO ₄) ₃ (OH)	calcium hydroxyapatite
CEC	cation exchange capacity
CH	coconut husk mesocosm
C:N	carbon: nitrogen
COD	chemical oxygen demand
CS	crushed cockle shell mesocosm
Cu	Copper
DEP	Department of Environmental Protection Pennsylvania
DID	Department of Irrigation and Drainage Malaysia
DIN	dissolved inorganic nitrogen
DO	dissolved oxygen

DOC	dissolved organic carbon
DOE	Department of Environment Malaysia
DON	dissolved organic nitrogen
EMCs	event mean concentrations
EQR	Environment Quality Report Malaysia
Fe	iron
H ₃ PO ₄	Orthophosphate
HRT	hydraulic retention time
LMW	low molecular weight
MLR	multilinear regression analysis
MSMA	Manual Saliran Mesra Alam
N	nitrogen
N ₂ O	nitrous oxide
NH ₃ -N	ammonical nitrogen
NJDEP	New Jersey Department of Environmental Protection
NO ₂ -N	nitrite-nitrogen
NO ₃ -N	nitrate-nitrogen
NO _x -N	oxidized nitrogen
NP	shredded newspaper mesocosm
NPDES	National Pollutant Discharge Elimination Systems
NV	non-vegetated mesocosm
NWQS	national water quality standard
O ₂	oxygen gas
P	phosphorus
Pb	lead

PCA	principle component analysis
PGC	Prince George's County Maryland
PO ₄ ³⁻	phosphate
PON	particulate organic nitrogen
PP	shredded printed paper mesocosm
PSD	particle size distribution
PUB	Singapore Public Utility Board
PVC	polyvinyl chloride
REDAC	River Engineering and Urban Drainage Research Centre
SD	standard deviation
SEM	scanning electron microscope
SS	suspended solids
STD	standard mesocosm
TC	tyre crumb mesocosm
TDN	total dissolved nitrogen
TDP	total dissolved phosphorus
TDS	total dissolved solids
TKN	Total Kjeldahl Nitrogen
TN	total nitrogen
TOC	total organic carbon
TP	total phosphorus
TSS	total suspended solids
UK	United Kingdom
US	United States
USDA	United States Department of Agriculture

USEPA	United States Environmental Protection Agency
V	vegetated mesocosm
VSSF	vertical subsurface flow constructed wetlands
WQI	water quality index
WSUD	Water Sensitive Urban Design Australia
WTR	water treatment residue
Zn	zink

LIST OF SYMBOLS

\mathcal{E}	Error
β	Relevant parameters
$\Delta Canopy$	Canopy growth rate
$\Delta Canopy_{media}$	Average canopy growth rate for each media type
ΔH	Height growth rate
ΔH_{media}	Average height growth rate for each media type
$\Sigma \Delta Canopy_{media}$	Total average canopy growth rate
$\Sigma \Delta H_{media}$	Total average height growth rate
ΣF_{media}	Total number of flower
ΣM_{media}	Total plant achieved maturity
C_{eff}	Effluent concentration
\overline{C}_{eff}	Mean effluent concentration
C_{inf}	Influent concentration
\overline{C}_{inf}	Mean influent concentration
C_R	% concentration reduction
C_S	Saturated DO concentration
$Canopy_f$	Final canopy width
$Canopy_i$	Initial canopy width
d_{50}	Diameter of particle size that intercept at 50% of the cumulative mass
df	Degree of freedom
DO_x	Measured DO
DO_{sat}	Dissolved oxygen saturation percentage

e	Residuals
F	Factor
F_{media}	Number of flower for each media type
H_0	Null hypothesis
H_f	Final height
H_i	Initial height
k	Hydraulic conductivity
k_s	Saturated hydraulic conductivity
L	Depth of bioretention media
M_f	Final sample mass
M_i	Initial sample mass
M_{media}	Number of plant achieved maturity for each media type
MS	Mean square
M_{total}	Cumulative mass removal
p	Ponding depth
Q	Infiltration flow rate
r	Pearson's correlation coefficient
R^2	Coefficient of determination
R_{Canopy}	Canopy growth ratio
R_F	Flower ratio
R_H	Height growth ratio
R_M	Maturity ratio
S	Cross section of the column
$Sig.$	Significance
SS	Sum of square

SS_{res}	Sum of squares of residuals
SS_{tot}	Total sum of squares of the deviations
$Vol.$	Volume
$Vol_{.eff}$	Effluent volume
$Vol_{.inf}$	Influent volume
X	Independent variables
Y	Dependent variables

**PENGARUH MEDIA *BIORETENTION* YANG DITAMBAH BAIK DAN
POKOK RENEK TROPIKA TERHADAP PENGURANGAN NUTRIEN
DALAM AIR LARIAN BANDAR DI KAWASAN PEMBANGUNAN
BERCAMPUR**

ABSTRAK

Input nutrisi daripada aliran air bandar terutamanya nitrogen (N) dan fosforus (P), merupakan masalah utama dalam perlindungan ekosistem akuatik. Kajian makmal ini bertujuan menyiasat penambahbaikan sistem *bioretention* untuk mengetahui prestasi dan mengoptimalkan komposisi bahan tambahan dalam media *bioretention* bagi menyingkirkan nutrisi, dan menyiasat potensi fitopemuliharaan *Hibiscus rosa-sinensis* (bunga raya) dalam sistem *bioretention* melalui kajian tanah dan tumbuhan. Kajian ini dijalankan dalam dua peringkat. Pada Peringkat 1, kajian dilakukan dengan mengubahsuai media *bioretention* dengan 10% (mengikut isi padu) bahan tambahan dari pelbagai bahan-bahan buangan (kulit kerang, akhbar, kertas bercetak, sabut kelapa, dan remah tayar) dan ditanam dengan *Hibiscus rosa-sinensis*. Hasilnya, media yang diubahsuai dengan hirisan akhbar (NP) menunjukkan jumlah penyingkiran pepejal terampai (TSS) tertinggi (98.4%), berbanding dengan media *bioretention* standard (STD, 85.4%), dan menunjukkan peningkatan yang ketara dalam penyingkiran jumlah nitrogen (TN, 80.4%), berbanding dengan STD (57.5%) apabila disiram dengan air larian sebenar. Medium yang diubahsuai dengan hancuran kulit kerang (CS) menunjukkan jumlah penyingkiran fosforus (TP) yang paling tinggi (93.3%), berbanding dengan STD (84.8%), dan media ini juga menunjukkan pertumbuhan pokok yang lebih baik, berbanding dengan media lain. Oleh itu, NP dan CS telah dipilih untuk kajian di Peringkat 2, dan tiga jenis komposisi media (komposit