RELATIONSHIP BETWEEN RUNOFF COEFFICIENT AND CURVE NUMBER FOR SUNGAI WENG AND SUNGAI KAYU ARA CATCHMENTS

By

ASNOR MUIZAN BIN DATO' HJ. ISHAK

Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the requirement for the Degree of Master of Science

March 2006

DEDICATIONS

To my beloved

father

Dato' Hj. Ishak bin Idris

mother

Datin Asmah binti Md. Rashid

wife

Sarina bte Abdullah

sons

Asnor Amirul Bukhari bin Asnor Muizan
Asnor Azim Khaliq bin Asnor Muizan

brothers and sisters

Asran bin Dato' Hj. Ishak
Izuan bin Dato' Hj. Ishak
Razidan bin Dato' Hj. Ishak
Asnor Juraiza binti Dato' Hj. Ishak
Asnor Zumairi bin Dato' Hj. Ishak
Asnor Mazuan bin Dato' Hj. Ishak
Asnor Nadirah binti Dato' Hj. Ishak

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science

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March 2006

Chairman : Associate Professor Abdul Halim bin Ghazali, PhD

Faculty : Engineering

Traditionally, the rational formula that embodies runoff coefficient in the equation has widely been used for drainage design due to its simplicity. Two widely used design manuals that are particularly related to the rational formula in Malaysia are the Hydrological Procedure No. 16 (HP16) - Flood Estimation for Urban Areas in Peninsular Malaysia and Hydrological Procedure No. 5 (HP5) - Rational Method of Flood Estimation for Rural Catchments in Peninsular Malaysia. The latter presents the runoff coefficient that have been derived using the statistical approach rather than the deterministic, however, the former shows the look-up table of runoff coefficients that are adopted from few previous efforts that were carried out by some local authorities. The HP16 however has been superceded by the Urban Stormwater Management Manual (MSMA) in 2001, but the runoff coefficients proposed in the manual have been directly adopted from Australian practice.

This study attempts primarily to derive runoff coefficient and runoff curve number in two small catchments [1] urban catchment of Sungai Kayu Ara (more than 48.81% urbanized), and [2] forest catchment of Sungai Weng by using the deterministic approach. The other popular method that is widely used in hydrology is the Soil Conservation Services (SCS)

method, which uses runoff curve number (CN), which has several advantages against the rational method partly because of its flexibility in generating flood hydrograph. In this study, the primary objective was to formulate the relationship between the runoff coefficient (C) and runoff curve number (CN) such that the coefficients can be easily determined for catchments of similar characteristics.

The results show that the runoff coefficient and runoff curve number from the forest catchment were in the range of 0.05 to 0.30 and 44 to 64 respectively; for the urban catchment it was found to be in the range of 0.30 to 0.65 and 64 to 97. The average C for the forest and urban catchments were 0.13 and 0.55 respectively; while the average CN were about 52 and 83 respectively. There was no linear relationship between the two coefficients; however the relationship has been established using logarithmic fit which results in the correlation coefficient, r= 0.54 and 0.78 for the forest and urban catchment respectively. Runoff coefficients calculated using the relationship proposed by Chen have been compared with the values obtained in this study. The results show a good agreement for the forest catchment but a slightly poorer agreement in the urban catchment. The SCS initial abstraction factor (K) and peaking factor (F) are also determined in this study.

Abstrak tesis dikemukan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains

HUBUNGAN DI ANTARA PEKALI ALIRAN DENGAN NOMBOR LENGKUNG BAGI KAWASAN TADAHAN SUNGAI WENG DAN SUNGAI KAYU ARA

Oleh

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Mac 2006

Pengerusi : Profesor Madya Abdul Halim bin Ghazali, PhD

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Secara tradisi, persamaan mudah formula rational dapat menghasilkan pekali air larian (C) yang telah diguna pakai secara meluas di dalam pengiraan merekabentuk sistem pengairan. Terdapat dua manual rekabentuk yang berkaitan dengan formula rational di Malaysia iaitu Prosedur Hidrologi No. 16 (HP 16) – Pengiraaan Banjir untuk Kawasan Bandaran di Semenanjung Malaysia dan Prosedur Hidrologi No. 5 (HP 5) – Formula Rational bagi Pengiraan Banjir untuk kawasan tadahan pendalaman di Semenanjung Malaysia. Kemudian penghasilan pekali air larian akan didemotrasikan dengan menggunakan kaedah statistik selain dari menentukannya, walau bagaimanapun ia akan ditunjukan di dalam jadual kajian ini bagi pekali air larian di mana ia telah diterima pakai oleh beberapa pihak berkuasa tempatan sebelum ini. Walau bagaimanapun, HP 16 telah diolah bersama dengan Manual Saliran Mesra Alam (MSMA) pada tahun 2001 tetapi pekalinya telah diperolehi secara terus daripada hujan di Australia.

Percubaan awal kajian ini adalah untuk menghasilkan pekali air larian dan nombor lengkung air larian (CN) di dua kawasan tadahan kecil iaitu [1] kasawan tadahan bandaran di Sungai Kayu Ara (lebih kurang 48.81% kawasan bandar) dan [2] kawasan tadahan hutan di Sungai Weng dengan menggunakan pengenalpastian selain menggunakan kaedah statistik seperti yang telah digunakan di dalam HP 5 sebelum ini. Selain kaedah rational satu prosedur mudah telah dihasilkan iaitu *Soil Conservation Service* (SCS), nombor lengkuk air larian (CN) di mana ia telah dikenal pasti kelebihannya berbanding dengan persamaan-persamaan lain di mana ia lebih fleksibel dalam menghasilkan hidrograf banjir. Namun begitu objektif utama kajian ini adalah untuk menghasilkan hubungan antara pekali air larian (C) dan nombor lengkung air larian (CN) dalam bentuk formula matematik; akhirnya pekali tersebut boleh ditukar ganti atau diguna pakai di dalam kawasan tadahan yang mempunyai kriteria yang sama.

Keputusan kajian ini menunjukan pekali air larian dan nombor lengkung air larian di kawasan tadahan hutan adalah dalam lingkungan 0.05 hingga 0.30 dan 44 hingga 64; namun begitu bagi kawasan tadahan bandaran pula di dalam lingkungan 0.30 hingga 0.65 dan 64 hingga 97. Secara umumnya dalam kajian ini memperolehi purata C di kawsan tadahan hutan dan bandaran ialah 0.13 dan 0.55, manakala purata CN telah dikira nilainya antara 52 dan 83. Tiada hubungan secara linear terbentuk untuk dua pekali ini, walau bagaimanapun hubungannya telah berjaya dikaitkan dengan menggunakan persamaan fit logaritma di mana keputusan hubungkait pekali, r = 0.59 dan 0.78 untuk kawasan tadahan hutan dan bandaran. Hubungan pekali air larian dan nombor lengkung air larian dari kajian Chen's telah diguna pakai di dalamn kajian ini bagi mengesahkan keputusan yang diperolehi; dimana

perbezaannya menunjukkan satu keputusan yang baik di kawasan tadahan hutan tetapi agak kurang baik sedikit di kawasan tadahan bandaran. Ditentukan juga di dalam kajian ini parameter-parameter di dalam formula SCS seperti faktor pemisahan awal (K) dan faktor puncak (F)

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I certify that an Examination Committee has met on 2nd March 2006 to conduct the final examination of Asnor Muizan bin Dato' Hj. Ishak on his Master of Science thesis entitled "Relationship between Runoff Coefficient and Curve Number for Sungai Weng and Sungai Kayu Ara Catchments" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulations 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfillment of the requirements for the degree of Master Science. The members of the Supervisory Committee are as follows:

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DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

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ASNOR MUIZAN BIN DATO' HJ. ISHAK

Date :

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LIST OF ABBREVIATIONS

Symbol	Description
&	And
AMC	Antecedent Moisture Condition
BF	Baseflow
L	basin lag time (feet)
Catch.	Catchment
A	Catchment area (sq. km)
cumecs	Cubic meter per second (m^3/s)
cusecs	Cubic feet per second (ft^3/s)
f	Cumulative infiltration (mm)
DID	Department of Irrigation and Drainage
R^2	Coefficient of determination
DRO	Direct runoff
Q	Direct Runoff (mm)
D	Duration of the unit excess rainfall (hr)
P_e	Effective rainfall (mm)
I_e	Effective rainfall intensity (mm/hr)
EV	Estimated value
ft	Feet
hr	Hour
HSG	Hydrologic Soil Groups
HP	Hydrological Procedure
in	Inches
I_a	Initial abstraction (mm)

K	Initial abstraction factor
I	Intensity of rainfall of chosen frequency for a duration equal to the time of concentration t_c (mm/hr)
MSMA	Manual of Stormwater Management or Manual Saliran Mesra Alam
mi	Miles
mm	Millimeters
N	Number of observations
Obs.	Observed data
OV	Observed value
a	Parameter
F	Peaking factor
Q_p	Peak discharge (m^3/s)
q_p	Peak flow per unit area (m^3/s /sq. km)
ϕ	Phi – index (mm/hr)
S	Potential maximum retention (mm)
t_p	Rainfall duration either effective or total (hour)
T_r	Recession limb time (hr)
I_a	Rainfall intensity (mm/hr)
R1	Rainfall Station no. 1
RF	Rainfall
RME	Relative mean error
T	Return period (year)
C	Runoff coefficient, variable with land use
CN	Runoff Curve Number
V_p	Runoff volume (mm)

	sec	Seconds
	Sg.	Sungai or River
	SCS	Soil Conservation Service
	S.I unit	Standard International Unit
	t_o	Time from the most remote part of the catchment to reach the point being considered and is the sum of the overland flow time (hour)
	t_c	Time of concentrations (hour)
t_d	t_d	Time of flow in the drain (hour)
	T_b	Time base (hr)
	T_p	Time to peak (hr)
	t_p	Time to peak (hr)
	P	Total rainfall (mm)
	UH	Unit Hydrograph
	USA	United State of America
	W1	Water Level Station no. 1
	W4	Water Level Station no. 4
	b	is an index which depends on AMC, vegetative cover, land use, time of the year, storm duration, and soil type