

UNIVERSITI TEKNOLOGI MARA

TECHNICAL REPORT

A GENERIC MATHEMATICAL MODEL FOR
ESTIMATING WATER CONSUMPTION IN
RESIDENTIAL PREMISES

P11S19

NUR SAHIRAH BINTI ROSLI
NURUL NURATIKAH BINTI ZAINAL
SAKINAH BINTI MOHD JAMAL

Bachelor of Science (Hons.) Mathematics
Faculty of Computer and Mathematical Sciences

DECEMBER 2019

ACKNOWLEDGEMENTS

IN THE NAME OF ALLAH, THE MOST GRACIOUS, THE MOST MERCIFUL

Firstly, I am grateful to Allah S.W.T for giving me the strength to complete this project successfully.

We take this opportunity to express our profound gratitude and deep regards to our guidance Dr. Khairul Anwar Rasmani for his monitoring and constant encouragement throughout this research. Without him, we would not be able to complete this project. Besides, a thank you to Puan Nur Azlina Binti Abd Aziz who had given us a piece of good advice, providing useful information to us, and also for her kindness in helping us during the process of completion of this project work. Every great experience requires the help, cooperation and support from many people for this project to be truly good. We would like to take the opportunity of thank all those who extended a helping hand whenever, we needed one. The blessing, help, and guidance given by our supervisor and lecturer from time to time shall carry we along the way in the journey of life on which we are about to embark. Lastly, we would like to thank our parents, siblings, as well as friends for their constant encouragement to all of us- without their great support, the successful completion of this report would not have been possible.

TABLE OF CONTENTS

ACKNOWLEDGEMENTS	ii
TABLE OF CONTENTS.....	iii
LIST OF TABLES.....	iv
LIST OF FIGURES	iv
ABSTRACT	v
I INTRODUCTION	1
1.1 Problem Statement	2
1.2 Objectives	3
1.3 Scope and Limitation	3
1.4 Significance of Study	4
2 BACKGROUND THEORY AND LITERATURE REVIEW	5
2.1 Domestic Water Consumption Estimation	5
2.2 Variables Used for Estimation of Domestic Water Usage	7
2.3 Existing Methods Used to Estimate Individual Water Consumption	9
2.4 Percentage of Water Usage for Individual Consumptions	11
2.5 Summary and Discussion	12
3 METHODOLOGY AND IMPLEMENTATION.....	13
3.1 Research Framework.....	13
3.2 The Proposed Method	15
3.2.1 Basis of the Model Development	15
3.2.2 Model Formulation	15
3.3 Validation Method	18
4 IMPLEMENTATION, RESULTS AND DISCUSSION	19
4.1 Improvisation of the Proposed Method	19
4.2 The Developed General Model to Estimate Domestic Water Consumption	20
4.3 Analysis of Results.....	22
4.3.1 Analysis between the Number of Households with Estimated Water Consumptions Using the Proposed Method, Average Monthly Meter Reading and Total PCC	22
4.3.2 Analysis on the Comparison between Total Estimated Consumptions Using the Proposed Method with the Average Monthly Meter Reading and PCC	25
4.3.3 Analysis of Possible Water Leakage based on Meter Reading.....	28
4.4 Validation	30
5 CONCLUSIONS AND RECOMMENDATIONS	31
REFERENCES.....	33
APPENDIX A	36

LIST OF TABLES

Table 2.1. Analysis on variables used for predicting domestic water usage	7
Table 2.2. Analysis on variables used in online water usage calculator for predicting domestic water usage	8
Table 2.3. Summary of main water usage activities for predicting domestic water usage..	9
Table 4.1. A general mathematical model for each type of activity	21
Table 4.2. List of experiment and/or analysis	22
Table 4.3. Relationship between estimated consumptions using the proposed method with PCC and the average monthly meter reading	26
Table 4.4. The comparison of model error based on RMSE	30
Table 4.5. Comparison of online water usage calculator based on RMSE	31

LIST OF FIGURES

Figure 3.1. Flowchart of research activities	13
Figure 3.2. Testing and validation process	14
Figure 4.1. Relationship between number of households and estimated consumption	23
Figure 4.2. Relationship between number of households and average monthly meter reading	24
Figure 4.3. Relationship between number of households and total PCC	25
Figure 4.4. The comparison between EC1, EC2, total water usage based on the average monthly meter reading and total PCC	27
Figure 4.5. (a)-(b): Comparison between EC1 and EC2 with total PCC	27
Figure 4.6. (a)-(b): The comparison between EC1 and EC2 and total water usage based on the average monthly meter reading	28
Figure 4.7. (a)-(c): The differences amount between estimated consumptions, average monthly water usage and amount of water usage during leaking	29

ABSTRACT

Modelling domestic water usage involves several components of water usage activities. Therefore, in general, the model consists several different variables depending on the water usage activities that are performed by the household. This leads to difficulties in estimating domestic water usage by using online water usage calculator. In this research, a new mathematical model is developed which offers flexibility in term of variable representing a component of domestic water usage. Additionally, the total water usage for each micro-components can be determined by using any function, $f(t)$ where t representing the duration (time) of each water usage activities. It may also contain the frequency of water usage activities.

The developed model has been tested using a set of consumers' data consisting water components variable related to domestic water usage activities. The finding shows water consumption predicted by the developed model are comparable to total water consumption based on per capita consumption (PCC) provided by the authority and average monthly meter reading provided by the consumer. Based on the result of validation, the differences between the value of error of the total consumption based on the proposed method with the total PCC and the average monthly meter reading did not show big changes. Meanwhile, the gap of the validation result between the two selected existing online water usage calculators with the total PCC and the average monthly meter reading are large. These results indicate that the proposed method produced reliable result and suitable to be used in estimating domestic water usage. The proposed method can also potentially be used to predict possible water leakage problem by conducting analysis between estimated water consumption between the proposed method and the water consumption is known as the average monthly meter reading.