



UNIVERSITI PUTRA MALAYSIA

***EVAPORATION REDUCTION AND PREDICTION
MODEL FOR RESERVOIRS***

MOSTAFA ALI MOHAMED BENZAGHTA

FK 2011 117

**EVAPORATION REDUCTION AND PREDICTION
MODEL FOR RESERVOIRS**

By

MOSTAFA ALI MOHAMED BENZAGHTA

Thesis Submitted to the School of Graduate Studies, Universiti Putra
Malaysia, in Fulfilment of the Requirements for the Degree of Doctor
of Philosophy

September 2011

DEDICATIONS

*In the name of Allah SWT, the Benevolent, the Beneficent and the Most Merciful
I dedicate this thesis to the soul of my parents: Haj Ali M. Benzaghta and Haja
Halema M. Kaleel for their encouragement and steadfastness since the beginning
of my educational career till I obtained my bachelor's degree. The thesis is also
dedicated to my wife Mrs. Naima Abuzed Abobaker for her understanding,
sacrifice and endurance during the course of this study and my sons: Mohamed,
Loai and Ali.*

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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MOSTAFA ALI MOHAMED BENZAGHTA

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Chairman: Professor Thamer Ahamed Mohamed, PhD

Faculty: Engineering

In this study, experiments were carried out at the Universiti Putra Malaysia, Faculty of Engineering in order to investigate the performance of different types of covers for evaporation reduction. The covers used were *Mengkuang* mat, pieces of plywood and galvanized iron corrugated sheet. The performance of the covers was tested using four *PVC* tanks. Measurement from the tanks revealed that evaporation reduction using *Mengkuang* mat was approximately 64% while it were about 50% and 36% for tanks covered with plywood and that shaded with a corrugated sheet respectively. The results obtained from experiments show that significant evaporation saving are possible if covers are used as barriers between water and atmosphere.

Water samples were collected weekly from the four tanks to assess the impact of selected covers on water quality. The collected samples were taken to the laboratory and physical and chemical water quality analysis was conducted. The

analysis included testing pH , EC , T_w , DO , BOD and COD . Test results were compared with the standards. The comparison revealed that there was a minor change in water quality of the covered tanks compared to the uncovered. These results confirmed the effectiveness of the covers in evaporation reduction with no harmful effects on water quality.

In this study, models for predicting evaporation from reservoirs were proposed. The models were based on the concept of Neural Network. The proposed models were applied to predict the evaporation from two selected reservoirs. One of these reservoirs is Algardabyia Reservoir (located in Libya), while the second one is Batu Dam Reservoir (located in Malaysia). The meteorological data used to run the proposed models were air temperature (T), wind speed (W), relative humidity (RH), and solar radiation (R_s) for the period from 1997 to 2008. Data from 1997 to 2005 was used for models training and validation. Data from 2006 to 2008 was used for model testing.

The proposed models simulating the evaporation from Algardabyia Reservoir was named (based on the number of input data) as $EM4-G$, $EM3-G$ and $EM2-G$. The same basis is used to name the models proposed for Batu Dam Reservoir. These models are $EM4-B$, $EM3-B$ and $EM2-B$.

Outputs from the proposed models were validated and it was found in agreement with the historical records. The validation process was based on computing selected statistical indices such as $RMSE$, MBA , MAE , R^2 , CE and d . The computed indices show that $EM4-G$ and $EM4-B$ models gave the most accurate predictions.

Also, selected climate based models such as Penman (*Pen*) and Priestley-Taylor ($P - T$) were used to predict the evaporation from the Algardabyia Reservoir and Batu Dam Reservoir. The performance of $P - T$ model was found to be better than the *Pen* model.



Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

PENGURANGAN SEJATAN DAN MODEL RAMALAN SEJATAN UNTUK TAKUNGAN

Oleh

MOSTAFA ALI MOHAMED BENZAGHTA

September 2011

Pengerusi: Profesor Thamer Ahamed Mohamed, PhD

Fakulti: Kejuruteraan

Dalam kajian ini, ujikaji ke atas pengurangan penyejatan telah dijalankan di Fakulti Kejuruteraan Universiti Putra Malaysia. Ujikaji ini telah bermula dan dengan menggunakan empat tangki *PVC* dan tangki penyejatan Kelas A bertujuan meneliti pencapaian bagi setiap jenis penutup yang berbeza bagi mengurangkan kadar penyejatan. Penutup yang digunakan adalah tikar *mengkuang*, kepingan papan lapis, dan atap zink (digunakan sebagai pelindung di atas permukaan air). Satu tangki dibiarkan tidak ditutup sebagai perbandingan kepada tangki-tangki yang ditutup. Sukatan penyejatan diambil setiap hari dari setiap tangki selama setahun. Sukatan dari tangki yang dirawat menunjukkan pengurangan kadar sejatan dengan menggunakan tikar *mengkuang* adalah sebanyak kira-kira 64% sementara dari tangki-tangki yang ditutup dengan papan lapis dan atap zink, adalah masing-masing 50% dan 36%. Hasil kajian menunjukkan penjimatan kadar penyejatan yang ketara boleh berlaku sekiranya penutup digunakan sebagai pemisah antara air dan atmosfera.

Sampel air diambil setiap minggu dari lokasi tertentu dalam setiap tangki. Sampel-sampel termasuklah pH , EC , Tw , DO , BOD dan COD . Hasil ujikaji kemudiannya dibandingkan dengan piawaian yang. Hasil perbandingan menunjukkan terdapat perubahan kecil pada kualiti air dari tangki yang ditutup berbanding tangki tanpa penutup. Hasil kajian ini telah mengesahkan keberkesanan bahan yang dicadangkan bagi mengurangkan kadar penyejatan.

Di dalam kajian ini, model bagi menganggar kadar penyejatan daripada takungan telah juga dicadangkan. Model tersebut adalah berdasarkan kepada konsep Rangkaian Saraf (Neural Network). Model ini boleh digunakan untuk simulasi proses penyejatan daripada takungan di kedua-dua kawasan yang kering dan lembap. Model ini telah digunakan bagi menganggarkan kadar penyejatan daripada dua takungan yang terpilih. Takungan pertama terletak di kawasan kering (Libya) dan dikenali sebagai Empangan Algardabyia manakala takungan kedua terletak di lokasi yang lembap (Malaysia) dan dikenali sebagai Empangan Batu. Data meteorologi yang digunakan bagi model cadangan adalah suhu (T), halaju angin (W), kelembapan relatif (RH) dan sinaran suria (Rs) daripada tahun 1997 sehingga 2008 untuk kedua-dua takungan. Data meteorologi harian untuk tempoh sembilan tahun (1997-2005) telah digunakan sebagai model perlatihan dan pengesahan. Model tersebut diuji menggunakan data meteorologi harian untuk tempoh tiga tahun (2006-2008).

Di dalam kajian ini, model cadangan yang mensimulasikan penyejatan daripada Empangan Algardabyia dinamakan sebagai $EM4 - G$, $EM3 - G$ dan $EM2 - G$. Asas yang sama juga digunakan bagi penamaan model simulasi penyejatan daripada Empangan Batu dan model tersebut dinamakan sebagai $EM4 - B$, $EM3 - B$ dan $EM2 - B$.

Hasil bagi model (penyejatan) tersebut telah disahkan dan didapati menepati jangkaan sama seperti rekod sejarah. Proses pengesahan adalah berdasarkan pengiraan indek statistik $RMSE$, MBA , MAE , R^2 , CE dan d . Indek pengiraan ini menunjukkan bahawa model $EM4-G$ dan $EM4-B$ menghasilkan jangkaan yang paling jitu.

Model berasaskan iklim, Penman (Pen) serta Priestley-Taylor ($P-T$) telah dipilih untuk menjangkakan penyejatan dari Empangan Algardabyia dan Empangan Batu. Prestasi bagi model $P-T$ didapati lebih baik berbanding model Pen .

ACKNOWLEDGEMENTS

Glorified and exalted is the Lord of Universe Who enabled His slave to develop a evaporation model and He is further implored to make this study beneficial to mankind.

I would like to express the most sincere appreciation and heartfelt gratitude to those whose contributions collectively were of immeasurable value in my educational pursuits. I wish to extend special appreciation and thanks to my supervisor Associate Professor Dr. Thamer Ahamed Mohammed for his patience, constructive critique, valuable suggestions and full guidance during the prolong period of my study. Unuttered dignified treatment received from him shall remain pleasant and valuable memories of this arduous study.

Deep gratitude and sincere appreciation also extended to Associate Professor Dr. Abdul Halim Ghazali and Professor Ir. Dr. Mohd Amin Mohd Soom, members of supervisory committee, for their superb guidance, constructive suggestions and appraisal of the study.

I would like to thank the Libyan Ministry of Higher Education and Sirte University, Libya for the financial assistance given to me in order to pursue my doctoral research. Also I would like to thank Authority of Algardabyia Reservoir at Sirte, Libya and Malaysian Meteorological Department and Hydrology and Water Resources Division for providing me the data of evaporation and meteorological.

My thanks go to my friends, colleagues, and technicians, Fatai Bukola Akande, Abdul Samad Chandio and Ken Wai for their cooperation and handy help during

this study, En. Aminuddin B. Amdan and En. Nik M. Faiz for the technical support.

I owe my gratitude to my many friends and relatives in Libya for helping me to obtain the evaporation and meteorological data in Libya; Mohamed Abodina and Ahamed Abusatea are specially thanked in this regard. Last but not least, I wish to convey my sincere thanks and love to my wife and my sons for their sacrifices and patience throughout the duration of my study.

I certify that a Thesis Examination Committee has met on 29/09/2011 to conduct the final examination of Mostafa Ali Mohamed Benzaghta on his Doctor of Philosophy thesis entitled "**Evaporation Reduction and Prediction Model for Reservoirs**" in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

Members of the Thesis Examination Committee were as follows:

Bujang bin Kim Huat, PhD

Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairperson)

Wan Nor Azmin bin Sulaiman, PhD

Associate Professor
Faculty of Environmental Studies
Universiti Putra Malaysia
(Internal Examiner)

Badronnisa binti Yusuf, PhD

Faculty of Engineering
Universiti Putra Malaysia
(Internal Examiner)

Mohamed F, Dahab, PhD

Professor
University of Nebraska
United State of America
(External Examiner)

SEOW HENG FONG, PhD

Professor and Deputy Dean
School of Graduate Studies
Universiti Putra Malaysia

Date: 22 November 2011

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of **Doctor of Philosophy**. The members of the Supervisory Committee were as follows:

Thamer Ahamed Mohammed, PhD

Professor
Faculty of Engineering
Universiti Putra Malaysia
(Chairman)

Abdul Halim Ghazali, PhD

Associate Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

Mohd Amin Mohd Soom, PhD

Professor
Faculty of Engineering
Universiti Putra Malaysia
(Member)

BUJANG BIN KIM HUAT, PhD

Professor and Dean
School of Graduate Studies
Universiti Putra Malaysia

Date:

DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

MOSTAFA ALI MOHAMED BENZAGHI

Date: 29 September 2011

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