



UNIVERSITI PUTRA MALAYSIA

**ASSESSMENT OF RIVER WATER QUALITY
USING AN EXPERT SYSTEM**

PAUZIAH HANUM BINTI ABDUL GHANI

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- iv. Allocate the allowable pollution loading from every source identified in the catchment and recommend the most economically feasible treatment system
- v. For the beneficial use classes, the load duration curve provides the opportunity for standards to be established and load allocation among the various sources.
- vi. Enhancement system evaluation by different treatment technology option, data transformation and missing or no data
- vii. Increase the system capability to integrate the interface with GIS and cause-effect relationship models.

Thus the system can therefore contribute to support inform decision making, with the adoption of mathematical formulation in an understandable form and graphic representation to be applicable to real situations; assessment phase is responsible for analyzing the quantitative data processed into information; the application phase is to interpret and used it to obtain a final interpretation for corrective action and recommendation.



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By

PAUZIAH HANUM BINTI ABDUL GHANI

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

AUGUST 2010



DEDICATION

To

My Dear Husband

Noorhisham Hj. Mohd Alwi

And our one and only daughter

Nurkhairiyah

And our adorable cats

Kembang, Comel and Tabby

Abstract of thesis presented to the senate of the University Putra Malaysia in fulfillment
of the requirement for the degree of Doctor of Philosophy



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AUGUST 2010

Chairman : Associate Professor Mohd Kamil Yusoff, PhD

Faculty : Environmental Studies

This study is to develop an expert system to assess water quality for user to derive at a decision equivalent to an expert decision. The ES-RWQ was developed as simple yet reliable tool to assist user in assessing the status of the water quality and relating it to the source contributing to the water quality problem. The main objective is to build a prototype of ES-RWQ with an assessment method, and the ability to derive to a recommendation on the water quality problem. While the conventional models can provide an inside to the quality problem but being complex issue in itself, an effective method of extracting value added information from all sources to facilitate decisions on the implementation of cost-effective pollution prevention and control measurements still requires expert consultation.

Therefore a re-look at the process of managing water quality are critical and timely to ensure the strategies and actions planned will lead to measurable water quality



improvement. Reliable assessment tools are needed to effectively communicate the water quality data so that the data become an important part of finding solutions and decision making process. Expert system (ES-RWQ) aim to assist decision maker and water quality managers to decide on the most appropriate decision/action to be taken when confronting a situation which requires immediate action. ES-RWQ was developed using the visual basic programming language as the tool that consists of user interface, knowledge engine, and inference engine. The user interface can be construct using menu driven or natural language as the communication mode between user and the system.

Load duration curve has been identified as one of the assessment tool that offers a practical approach to watershed management. The duration curve has an added value due to its ability to perform a quick and reliable statistical analysis of data targeting the sources as well as linking it to the potential implementation efforts to the hydrologic condition of the watershed. The assessment of water quality was based on pollutant loading model establishing the load capacity of the river to determine specific limit for thr river in receiving pollutant. Selection of tools was based on the combination of prediction reliability with ease of use and reduced requirement of field data. A prototype developed using Microsoft Visual Basic and validated by selecting two sub-catchment from Melaka and one sub-catchment of upper Sungai Langat, Selangor. Four variables Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Ammoniacal Nitrogen (AN) and Total Suspended Solid (TSS) of different river classification standard were also selected to validate the ES-RWQ. The 20 years of flow data, the variables, and other information on the sub catchment were input into the prototype, for it to execute the knowledge and the inferences engine to ensure the system produced the

expected result. ES-RWQ, produced an output of a load duration curve as the assessment for the water quality status, with its graphical representation, map extract from the geographical information system and recommendation to control pollution source identified. When the information of sub-catchments were executed by the system the output performed as per the specification design for the system to function. Test run with the user agencies was conducted with three rivers; Sg. Pinang, Pulau Pinang, Sg. Jelai, Pahang and Sg. Kanowit, Sarawak. The ES-RWQ was agreed by user agencies as an assessment tool and loading capacity as a new approach to determine the status of water quality and identify sources of pollution. With effective knowledge management tool such as ES-RWQ will enhance decision making process and employing computer based-technology to capture knowledge and human expert knowledge as an added tool for river water quality management.

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

**PENILAIAN KUALITI AIR SUNGAI DENGAN MENGGUNAKAN
SISTEM PINTAR**

Oleh

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Kajian ini bertujuan untuk membina satu sistem pintar bagi pengguna yang bukan pakar dalam pengurusan air untuk menghasilkan sebuah keputusan yang setara dengan keputusan pakar. Sistem pintar bagi kualiti air sungai telah dibangunkan secara ringkas tetapi berkesan untuk membantu pengguna membuat penilaian terhadap status kualiti air dan menentukan sumber yang menjadi punca kepada masalah yang timbul. Objektif kajian ini ialah untuk mencipta sebuah prototaip sistem pintar yang dilengkapi dengan mekanisma penilaian dan kebolehan untuk menentukan dan mencadangkan punca yang menyumbang kepada masalah kualiti air. Sistem pintar ini juga boleh membantu pengguna yang kurang mahir untuk membuat keputusan bagi menyelesaikan masalah kualiti air yang memerlukan perhatian segera.



Masalah kualiti air memerlukan langkah rawatan segera daripada organisasi pengurusan dan melibatkan aplikasi pembuat keputusan yang ringkas, mudah dan fleksibel untuk digunakan. Walaupun sistem konvensional telah dilengkapi dengan pelbagai maklumat tambahan dari pelbagai sumber untuk memudahkan implementasi langkah pencegahan pencemaran, namun ia masih memerlukan khidmat nasihat daripada pakar untuk membuat keputusan yang berkesan.

Oleh itu, penelitian semula terhadap proses pengurusan kualiti air adalah amat kritikal dan tepat pada masanya bagi memastikan strategi serta pelan tindakan akan menghasilkan peningkatan yang signifikan serta realistik. Mekanisma penilaian yang berkesan adalah diperlukan bagi memproses data kualiti air agar ia menjadi sebahagian daripada entiti penting dalam proses mencari penyelesaian serta membuat keputusan. Kaedah Graf Tempoh Muatan (Load Duration Curve) telah dikenalpasti sebagai salah satu mekanisma penilaian yang berkesan dalam pengurusan kawasan lembangan. Graf berkenaan mempunyai nilai tambah dengan keupayaan untuk membuat analisa statistik mengesan sumber dan menentukan langkah penyelesaian yang paling berpotensi untuk diimplementasi secara pantas dan berkesan. Pengetahuan yang mendalam dalam bidang ini sangat penting untuk membina sebuah mekanisma pengurusan yang berkesan untuk menyelesaikan masalah alam sekitar. Sistem pengurusan pintar yang berkesan mampu meningkatkan kebolehan proses membuat keputusan dan mengimplementasi teknologi berasaskan komputer untuk mendapatkan maklumat dan khidmat nasihat yang setara dengan apa yang ditawarkan oleh pakar dalam bidang berkenaan.

Sistem pintar dalam pengurusan kualiti air sungai bertujuan untuk membantu pembuat keputusan dan organisasi yang menguruskan kualiti air menentukan keputusan dan tindakan yang sesuai apabila berhadapan dengan situasi yang memerlukan perhatian segera. Sistem ini dibangunkan menggunakan perisian *visual basic* yang terdiri daripada aplikasi pengguna antaramuka (user interface), enjin pengetahuan (knowledge engine) dan enjin inferens (inference engine). Pengguna antaramuka (user interface) boleh dibina menggunakan menu ataupun bahasa semulajadi sebagai mode komunikasi di antara pengguna dan sistem. Domain fakta masalah (problem domain facts) dan fakta kes yang spesifik berada di dalam enjin pengetahuan. Tindakan berdasarkan situasi diaktifkan oleh enjin inferens. Apabila corak maklumat dan keputusannya sudah selari, peraturan akan ditetapkan agar suatu tindakan boleh diambil. Perolehan pengetahuan adalah berdasarkan kepada dokumen yang sedia ada, temuramah dengan pakar dalam bidang berkaitan, dan tinjauan agensi yang berkeelayakan manakala perwakilan informasi adalah berdasarkan kepada peraturan proses. Dalam membangunkan sistem pintar untuk kualiti air sungai, tugas utama yang perlu dilaksanakan ialah perolehan maklumat dan perwakilannya. Penilaian kualiti air adalah berasaskan model muatan pencemaran melalui penghasilan muatan kapasiti sebagaimana diaplikasikan dalam penentuan muatan maksimum harian sungai-sungai di Amerika Syarikat. Pemilihan mekanisme atau kaedah pengaplikasian adalah berasaskan kepada kombinasi kebolehpayaan meramal, kebolegunaan serta minimum keperluan data yang perlu diperolehi. Satu prototaip telah dibangunkan menggunakan perisian *Microsoft Visual Basic* dan menjadikan Hulu Sungai Langat di Selangor, Hulu Sg. Melaka dan Sg. Durian Tunggal di Melaka sebagai kawasan kajian. Empat parameter telah digunakan iaitu keperluan

oksigen biokimia (BOD), keperluan oksigen kimia (COD), ammoniakal-nitrogen (AN) dan pepejal terampai (TSS) daripada klasifikasi sungai yang berlainan. Limpahan data selama 20 tahun, pembolehubah dan maklumat-maklumat lain di kawasan tersebut turut dimasukkan ke dalam prototaip agar operasi enjin pengetahuan dan inferens dapat menghasilkan keputusan yang tepat. Keputusan yang diberikan oleh sistem pintar mampu menghasilkan graf tempoh masa sebagai penilaian status kualiti melalui perwakilan grafik, serta peta yang diekstrak daripada sistem maklumat geografi. Apabila maklumat daripada kawasan kajian diproses, keputusannya adalah sebagaimana yang dispesifikasikan. Uji pakai ES-RWQ telah di jalankan di agensi yang terpilih seperti Jabatan Pengaliran Saliran dan Jabatan Alam Sekitar dengan menggunakan Sg. Pinang, Sg. Jelai dan Sg. Kanowit. Pegawai dari kedua-dua agensi sangat bersetuju bahawa ES-RWQ mempunyai potensi sebagai model penilaian kualiti air seperti yang di inginkan serta mengenalpasti punca-punca yang menyebabkan pencemaran air.

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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.

PAUZIAH HANUM ABDUL GHANI

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