



**UNIVERSITI PUTRA MALAYSIA**

***IMPROVING LEACHING EFFICIENCY OF SALINE SOILS USING WATER  
MANAGEMENT TECHNIQUES***

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**IMPROVING LEACHING EFFICIENCY OF SALINE SOILS USING  
WATER MANAGEMENT TECHNIQUES**

**By**

**ABDUL GHAFOOR SIYAL**

**Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia,  
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**June 2011**

**Chair: Prof Ir. Desa. Ahmad, PhD**

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Saline soils in arid regions of the world are normally reclaimed by continuous ponding method of the salt leaching. This method wastes large quantities of good quality water that otherwise may be used for irrigation of crops. In water stress region, water use efficient leaching methods are desperately needed. Therefore the salt leaching efficiency of different desalinization methods *viz.* partial, continuous and intermittent ponding were investigated for medium to fine soil textures i.e. sandy loam, loam, silt loam and clay soil under initially saturated conditions in the laboratory using sand tank model. Experiments of salt leaching from loamy soil with continuous and intermittent ponding under initially unsaturated conditions were also conducted.

Computer simulations of salt leaching with continuous and partial ponding scenarios under initially saturated and unsaturated conditions were also carried out with model HYDRUS-2D. Based on literature, a hypothesis that salt leaches quicker when a soil

is initially unsaturated was tested through a field experiment conducted on saline loamy soil. For uniform drying of the entire soil root zone, wheat plants were grown in plots based on random approach. Soil moisture content of these plots was compared to plots with only tillage and plots without tillage and wheat plants. Also, salt leaching from these plots was carried out using continuous and intermittent ponding so as to verify the hypothesis.

Laboratory study results revealed that up to 95% and 25% water was saved when partial and intermittent ponding methods were used to desaline different soil textures compared to continuous ponding. Partial ponding also consumed 89% and 92% less time compared to full and intermittent ponding methods, respectively.

Time taken to leach out 80% salts from loamy soil under initially saturated and unsaturated conditions with different leaching scenarios, show that with full ponding 10.9% less time was taken during leaching under initially unsaturated conditions compared to that of initially saturated conditions. Similarly time savings of 11.0% and 9.6% were obtained under initially unsaturated conditions compared to that of initially saturated conditions, when partial and intermittent ponding methods, respectively, were used for leaching.

For initially saturated soil conditions, salt leaching with partial ponding consumed about 95% less water and 90% less time taken to leachout 80% salts from tank compared to full and intermittent ponding respectively under laboratory conditions. Thus, partial ponding proved not only water use efficient method but also time saving method.

Extrapolation of the partial ponding technique for initially unsaturated soil conditions caused extra 8.1% and 11% water and time savings respectively compared to that used with under initially saturated soil conditions.

Computer simulations of salt leaching with HYDRUS-2D revealed that partial ponding method of leaching is a time efficient method of leaching which can save 90.6%, 90.7%, 89.5% and 88.5% time savings compared to continuous leaching for sandy loam, loam, silt loam and clay soil textures respectively.

Field experiments results showed that plants are capable of drying root zone, plants extracted water from the entire profile significantly which resulted in approximately uniform moisture content in the soil profile. For both leaching methods salts were leached more from upper layer (0-20 cm) compared with lower soil layer (60-80 cm) because the  $EC_w$  of water increases as the water percolates down to lower layers which results in decrease in concentration gradient between  $EC_e$  and  $EC_w$  and salts were leached more from plots with plants ( $T_3$ ) followed by plots with tillage ( $T_2$ ) and plots without tillage and plants ( $T_1$ ). Tillage expedites the leaching process but when the soil profile is unsaturated it enhances leaching capability even more. Intermittent ponding method of salt leaching found more efficient compared to that of continuous ponding method of leaching, however, intermittent method took 60 days whereas continuous method took 40 days to complete the leaching process.

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

**MENINGKATKAN KECEKAPAN LARUTLESAP TANAH MASIN  
MENGUNAKAN TEKNIK PENGURUSAN AIR**

oleh

**ABDUL GHAFOOR SIYAL**

**Jun 2011**

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Tanah masin di rantau gersang dunia biasanya ditebusguna dengan menakung air berterusan untuk melarutlesap garam. Kaedah ini banyak membazirkan air berkualiti baik yang sepatutnya dimanfaatkan untuk pengairan tanaman. Di rantau yang mengalami stres air, kaedah melarutlesap garam menggunakan air dengan cekap amatlah diperlukan. Oleh yang demikian beberapa kaedah nyahgaram yang cekap seperti kaedah genangan separa, berterusan, dan berkala telah dikaji menggunakan model tangki di makmal untuk tanah bertekstur sederhana hingga tekstur halus, iaitu lom berpasir, lom, lom berkelodak dan tanah liat dengan berkeadaan tepu pada permulaannya. Ujikaji larutlesap garam untuk tanah lom tak tepu pada asalnya dengan genangan air berterusan dan berkala juga telah dijalankan.

Simulasi komputer sinario larutlesap garam dengan genangan air berterusan dan separa dalam keadaan tepu dan tak tepu pada awalnya telah dijalankan menggunakan Model HYDRUS-2D. Berpandukan bahan literatur, satu hipotesis yang menyatakan garam akan

larutlesap dengan lebih cepat sekiranya keadaan awalnya adalah tak tepu telah diuji di tapak kajian di lapangan dengan tanah masin jenis lom. Untuk pengeringan seragam keseluruhan zon akar, pokok gandum telah ditanam dalam plot secara rawak. Kandungan lembapan tanah di plot telah dibandingkan dengan plot yang dibajak sahaja tanpa tanaman, dan plot tanpa dibajak tetapi ditanam gandum. Larutlesap garam dari plot secara genangan air berterusan dan secara genangan berkala telah dijalankan untuk mengesahkan hipotesis tersebut.

Kajian di makmal menunjukkan penjimatan air dapat dicapai sehingga 95% bagi genangan separa dan 25% bagi genangan berkala dibandingkan dengan genangan berterusan untuk menyahkan garam dari pelbagai jenis tekstur tanah. Genangan separa juga dapat mengurangkan masa sebanyak 89% berbanding dengan genangan penuh dan 92% bagi genangan berkala.

Masa diambil untuk melarutlesap 80% garam dari tanah lom dengan keadaan tepu dan tak tepu diawalnya dengan sinario larutlesap yang berbeza menunjukkan dengan genangan penuh, penjimatan masa sebanyak 10.9% diperolehi semasa proses larutlesap jika keadaan awal tak tepu berbanding dengan keadaan tepu. Penjimatan masa sebanyak 11% bagi kaedah genangan separa dan 9.6% bagi genangan berkala diperolehi dalam keadaan tak tepu berbanding dengan keadaan awal yang tepu dalam melarutlesap nyahgaram.

Untuk ujikaji keadaan tanah tepu di makmal, larutlesap garam dengan genangan separa menjimatkan air sekitar 95% untuk melarutlesap 80% garam dari tangki berbanding dengan genangan air berterusan, dan penjimatan 90% air untuk genangan berkala. Oleh

itu, genangan separa telah membuktikan bukan sahaja ianya kaedah penggunaan air yang cekap bahkan juga menjimatkan masa.

Ekstrapolasi teknik genangan separa untuk keadaan tanah yang asalnya tak tepu menyebabkan tambahan air sebanyak 8.1% dan tambahan masa sebanyak 11% berbanding dengan keadaan tanah yang asalnya tepu.

Simulasi computer larutlesap garam dengan HYDRUS-2D menunjukkan yang genangan separa adalah cekap dalam penggunaan masa dan dapat menjimatkan masa berbanding dengan genangan berterusan sebanyak 90.6%, 90.7%, 89.5% and 88.5%, masing-masing bagi lom berpasir, lom, lom bekelodak dan tanah liat.

Hasil ujikaji di lapangan menunjukkan tanaman dapat mengeringkan zon akar, mengambil air dari profil tanah dengan signifikan menghasilkan kandungan lembapan seragam di profil tanah. Untuk kedua-dua kaedah larutlesap, garam dilarutlesap dengan lebih banyak dari lapisan atas (0-20 cm) berbanding lapisan bawah (60-80 cm) kerana  $EC_w$  air meningkat apabila air turun ke bawah menjadikan pengurangan gradien kepekatan  $E_{Ce}$  dan  $EC_w$ . Garam dilarutlesap dengan lebih banyak dari plot yang ada tanaman (T3) diikuti oleh plot dibajak tanpa tanaman (T2) dan plot tanpa dibajak tapi ada tanaman (T1). Bajakan mempercepatkan proses larutlesap tetapi jika profil tanah berkeadaan tak tepu, larutlesap akan menjadi lebih baik. Kaedah genangan berkala untuk melarutlesap garam didapati lebih cekap berbanding dengan kaedah genangan berterusan; walau bagaimanapun kaedah genangan berkala mengambil masa 60 hari berbanding dengan 40 hari bagi genangan berterusan.



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I certify that an Examination Committee has met on 30 June, 2011 to conduct the final examination of Abdul Ghafoor Siyal on his thesis entitled “Improving leaching efficiency of saline soils through water management techniques” 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 Degree of Doctor of Philosophy.

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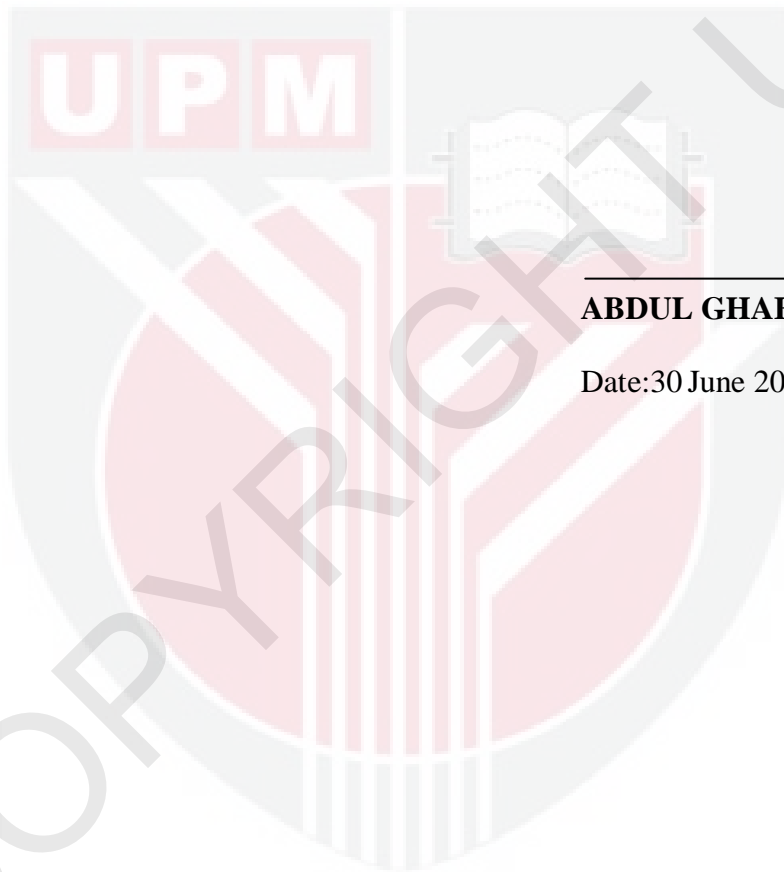
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## DECLARATION

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 currently, submitted for any other degree at Universiti Putra Malaysia or any other institution.



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**ABDUL GHAFOOR SIYAL**

Date:30 June 2011



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