



**UNIVERSITI PUTRA MALAYSIA**

**PADDY FIELD ZONE DELINEATION USING APPARENT  
ELECTRICAL CONDUCTIVITY AND ITS RELATIONSHIP TO THE  
CHEMICAL AND PHYSICAL PROPERTIES OF SOIL**

**AIMRUN WAYAYOK.**

**ITMA 2006 6**

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**By**

**AIMRUN WAYAYOK**

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

**March 2006**



## **Dedication**

From the depth of my heart, I dedicate this thesis to my beloved father Abdul Kimlee, mother Sapiyah, sisters Manisa and Warda, and brothers Mustafa, Sulaiman, Abdul Hadi and Anwar.

*~Atimrun Wayayok~*

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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**Chairman: Professor Ir. Mohd Amin Mohd Soom, PhD**

**Institute: Advanced Technology**

Spatial variability and temporal variability of soil chemical and physical properties within a field is unavoidable. Meanwhile, laboratory soil test is usually time consuming and laborious. To satisfy the concept of precision farming, rapid and intensive soil sampling is necessary for describing the uncertainty within a field. Apparent or bulk soil electrical conductivity ( $EC_a$ ) technique for describing soil spatial variability is widely used. A sensor known as VerisEC can measure the average  $EC_a$  of 0-30 cm (shallow  $EC_a$ ) and 0-90 cm (deep  $EC_a$ ) depths and locate its position by Differential Global Positioning System (DGPS) at every second.  $EC_a$  includes soil salinity and soil texture. Soil texture has high correlation with soil cation exchange capacity (CEC) hence, soil nutrient contents. The main purpose of this study was to generate variability map of soil  $EC_a$  within rice cultivation areas using VerisEC sensor for three seasons. The  $EC_a$  values were then compared to some soil chemical and physical properties namely pH, EC, OM, OC, total S, total N, available P, CEC, Ca, Mg, K, Na, Al, Fe, total cation, BS, ESP, dry bulk density, moisture content, clay, silt, fine sand, coarse sand and sand, within classes after delineation. The study site was 145 ha paddy fields at Block C, Sawah Sempadan in

the Tanjong Karang Rice Irrigation Scheme, Malaysia. The sensor was pulled by a tractor in a U-shape pattern between the field drains (speed = 15 km h<sup>-1</sup>). Disturbed and undisturbed of 236 sampling points were collected and recorded their positions by GPS (Trimble GeoExplorer3). Soil properties and EC<sub>a</sub> data were mapped using kriging technique on GS+ and ArcGIS. SPSS and SAS were used for their statistical analysis. The study showed that the EC sensor can determine soil spatial and temporal variability, where it can acquire the soil information quickly with less labour. Most of the soil properties and EC<sub>a</sub> changed from one season to other seasons, except total N. Much of the soil properties had the same mean values for seasons 1 and 3 such as K, moisture content, silt and coarse sand. Spatial variability of shallow and deep EC<sub>a</sub> had the same pattern for different seasons even though the mean values were different. Deep EC<sub>a</sub> showed the pattern of former canal routes clearly as continuous lines about 45 m wide at the northern and central parts of the study area. Low Na in zone 1 delineated by deep EC<sub>a</sub> may be due to deep soil profile to reach the parent material of marine alluvial, where it was a former water route. High fine sand and sand in zone 1 were found for all the seasons. The models of soil properties estimation based on EC<sub>a</sub> varied spatially and temporally from season to season and even from zone to zone. Most of them can be estimated better by deep EC<sub>a</sub> except, soil K and ESP. The selected models showed that the highest significant R<sup>2</sup> was found in fine sand and sand models with the consistency of the model throughout the study seasons. The relationship between yield and deep EC<sub>a</sub> was non significant for all the seasons.

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

**PEMBAHAGIAN ZON SAWAH PADI MENGGUNA KEBERKONDUKAN  
ELEKTRIK TANAH YANG TAMPAK DAN HUBUNGANNYA KEPADA  
CIRI KIMIA DAN FIZIKAL TANAH**

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Variasi ruang dan temporal bagi ciri kimia dan fizikal tanah dalam ladang tidak boleh dielakkan. Sementara itu, ujian tanah di makmal perlu banyak masa dan pekerja. Untuk memuaskan konsep perladangan persis, penyempelan tanah yang cepat dan giat adalah sangat perlu untuk menggambarkan ketidakpastian dalam ladang. Teknik keberkondukan elektrik tanah yang tampak atau seluruh ( $EC_a$ ) bagi huraian variasi ruang tanah diguna secara meluas. Penderia yang dikenali sebagai VerisEC boleh mengukur purata  $EC_a$  pada kedalaman 0-30 ( $EC_a$  cetek) dan 0-90 sm ( $EC_a$  dalam) dan diletak posisinya oleh Sistem Kedudukan Global Perbezaan (DGPS) pada setiap satu saat.  $EC_a$  dikaitkan dengan saliniti dan tekstur tanah. Tekstur tanah berkorelasi tinggi terhadap Keupayaan Pertukaran Kation (CEC) maka, kandungan baja dalam tanah. Tujuan utama bagi kajian ini adalah untuk menjanakan peta variasi bagi  $EC_a$  tanah dalam kawasan tanaman padi dengan menggunakan penderia VerisEC bagi tiga musim. Nilai  $EC_a$  kemudian dibandingkan dengan ciri kimia dan fizikal tanah iaitu; pH, EC, OM, OC, S keseluruhan, N keseluruhan, P yang berguna, CEC, Ca, Mg, K, Na, Al, Fe, kation keseluruhan, BS, ESP, kepadatan kering, kelembapan, lumpur, lempung, pasir halus, pasir kasar dan pasir di dalam kelas selepas

dibahagikan. Kawasan kajian ini adalah di ladang padi seluas 145 ha terletak di Blok C, Sawah Sempadan dalam Skim Pengairan Padi Tanjong Karang, Malaysia. Penderia telah ditarik dengan traktor berbentuk U diantara parit tengah (kalajuan =  $15 \text{ km j}^{-1}$ ). Titik sampel yang terganggu dan tidak terganggu bagi 236 sampel telah dikutip dan dirakamkan lokasinya oleh GPS (Trimble GeoExplorer3). Data ciri tanah dan  $\text{EC}_a$  telah dijanakan peta menggunakan teknik kriging diatas GS+ dan ArcGIS. SPSS dan SAS telah diguna untuk analisa statistik. Kajian ini menunjuk bahawa penderia EC boleh menentukan variasi ruang dan temporal tanah dimana ia boleh memperoleh maklumat tanah dengan cepat dengan kurang pekerja. Kebanyakan ciri tanah dan  $\text{EC}_a$  berubah dari satu musim ke satu musim yang lain melainkan, N keseluruhan. Banyak ciri tanah mengandungi nilai purata yang sama bagi musim 1 dan 3 seperti K, kelembapan, lempung dan pasir kasar. Variasi ruang bagi  $\text{EC}_a$  yang cetek dan dalam mempunyai bentuk yang sama bagi musim yang berbeza walaupun nilai puratanya berbeza.  $\text{EC}_a$  dalam menunjuk bentuk laluan sungai lama dengan jelas seperti garisan sambungan seluas 45 m di sebelah utara dan kawasan tengah bagi kawasan kajian. Na yang rendah di zon 1 yang dibahagikan oleh  $\text{EC}_a$  dalam mungkin disebabkan oleh profil tanah yang dalam untuk mencapai bahan asas lanar laut. Kandungan pasir halus dan pasir yang tinggi dalam zon 1 terdapat pada semua musim. Model anggaran ciri tanah berasaskan  $\text{EC}_a$  berbeza secara ruang atau temporal dari satu musim ke satu musim yang lain atau satu zon ke satu zon yang lain. Banyak ciri tanah baik dianggar oleh  $\text{EC}_a$  dalam melainkan, K dan ESP. Model yang terpilih menunjukkan bahawa  $R^2$  yang penting yang paling tinggi adalah terdapat pada model pasir halus dan pasir dengan model yang konsisten pada semua musim kajian. Hubungan diantara hasil dan  $\text{EC}_a$  dalam adalah tidak penting bagi semua musim.

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41	Isotrophic Variograms of Fe ( $\text{cmol}_{\text{c}} \text{ kg}^{-1}$ ).	4.45
42	Isotrophic Variograms of Total Cation ( $\text{cmol}_{\text{c}} \text{ kg}^{-1}$ ).	4.46
43	Isotrophic Variograms of BS (%).	4.47
44	Isotrophic Variograms of ESP (%).	4.49
45	Isotrophic Variograms of Dry Bulk Density ( $\text{g cm}^{-3}$ ).	4.50
46	Isotrophic Variograms of Moisture Content (%).	4.51
47	Isotrophic Variograms of Clay (%).	4.54
48	Isotrophic Variograms of Silt (%).	4.54
49	Isotrophic Variograms of Fine Sand (%).	4.55
50	Isotrophic Variograms of Coarse Sand (%).	4.55
51	Isotrophic Variograms of Sand (%).	4.56
52	Kriged Map for Shallow $\text{EC}_a$ ( $\text{mS m}^{-1}$ ) Classified by Standard DOA EC Rank (a) Season 1, (b) Season 2, and (c) Season 3.	4.62
53	Kriged Map for Deep $\text{EC}_a$ ( $\text{mS m}^{-1}$ ) Classified by Standard DOA EC Rank (a) Season 1, (b) Season 2, and (c) Season 3.	4.63
54	Kriged Map for Shallow $\text{EC}_a$ ( $\text{mS m}^{-1}$ ) Classified by Smart Quantiles (a) Season 1, (b) Season 2, and (c) Season 3.	4.67
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56	Kriged Map for pH Classified by DOA (a) Season 1, (b) Season 2, and (c) Season 3.	4.73

57	Kriged Map for pH Classified by Smart Quantiles (a) Season 1, (b) Season 2, and (c) Season 3.	4.76
58	Kriged Map for EC ( $\text{dS m}^{-1}$ ) Classified by Smart Quantiles (a) Season 1, (b) Season 2, and (c) Season 3.	4.79
59	Kriged Map for OM (%) Classified by Smart Quantiles (a) Season 1, (b) Season 2, and (c) Season 3.	4.82
60	Kriged Map for OC (%) Classified by Smart Quantiles (a) Season 1, (b) Season 2, and (c) Season 3.	4.84
61	Kriged Map for Total S (%) Classified by Smart Quantiles (a) Season 1, (b) Season 2, and (c) Season 3.	4.87
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63	Kriged Map for Avail. P (ppm) Classified by Smart Quantiles (a) Season 1, (b) Season 2, and (c) Season 3 Classified to Seasonal Smart Quantiles.	4.93
64	Kriged Map for CEC ( $\text{cmol}_c \text{ kg}^{-1}$ ) Classified by Smart Quantiles (a) Season 1, (b) Season 2, and (c) Season 3.	4.96
65	Kriged Map for Ca ( $\text{cmol}_c \text{ kg}^{-1}$ ) Classified by Smart Quantiles (a) Season 1, (b) Season 2, and (c) Season 3.	4.99
66	Kriged Map for Mg ( $\text{cmol}_c \text{ kg}^{-1}$ ) Classified by Smart Quantiles (a) Season 1, (b) Season 2, and (c) Season 3.	4.102
67	Kriged Map for K ( $\text{cmol}_c \text{ kg}^{-1}$ ) Classified by Smart Quantiles (a) Season 1, (b) Season 2, and (c) Season 3.	4.105
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69	Kriged Map for Al ( $\text{cmol}_c \text{ kg}^{-1}$ ) Classified by Smart Quantiles (a) Season 1, (b) Season 2, and (c) Season 3.	4.110
70	Kriged Map for Fe ( $\text{cmol}_c \text{ kg}^{-1}$ ) Classified by Smart Quantiles (a) Season 1, (b) Season 2, and (c) Season 3.	4.112
71	Kriged Map for Total Cation ( $\text{cmol}_c \text{ kg}^{-1}$ ) Classified by Smart Quantiles (a) Season 1, (b) Season 2, and (c) Season 3.	4.115
72	Kriged Map for BS (%) Classified by Smart Quantiles (a) Season 1, (b) Season 2, and (c) Season 3.	4.117
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