Research Article

Apparent Conductivity of Soil Salinity Profile of Marine Shrimp Aquaculture Farm

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Abstract

The Direct Current method was used to investigate the soil salinity profile of marine shrimp aquaculture farm comparing with the rice field. Finite difference method was used with the iterative technique to minimize the potential difference of the calculated and the measured potential to give an optimal solution rapidly. The iterative technique of Quasi-Newton was used and found to be robust with respect to starting models for both the synthesis and real data. The results showed the conductivities for both the rice field and the marine shrimp aquaculture farm varied between 0.15 S/m to 0.22 S/m and 0.15 S/m to 0.33 S/m, respectively. Those number of conductivities indicated that the salt or mineral deposit in the ground from marine shrimp aquaculture farm did not have much of an impact on the plant since the conductivity, which implied salt and mineral deposit, of the ground used for growing rice should not more than 0.40 S/m. Therefore, both ranges of conductivity of the ground could be used for orchard and paddy.

***Key Words*:** Environment; Finite difference; Salinity.

Introduction

Detection of the electrical anisotropy of geologic formation is a problem that has attracted the attention of geophysicists for many years. The motivation has varied greatly, ranging from groundwater investigation to hydrocarbon exploration (Barrett et al., 2006; Telford et al., 1996). There are many methods which were conducted to attack the problems such as Direct Current method, Electromagnetic method, Seismic method, Magnetometric method, and Magnetotelluric method. All of these methods can also be used to solve some of the related problems, for instance, the atmospheric and oceanic problems. In our study, the community problem concerning agriculture at Aumphor Banglen, Nakhon Pathom Province was intended to examined by us. The algorithm was conducted by using the Direct Current method to solve the disputed problem. A numerical algorithm that computed the conductivity of the ground of marine shrimp aquaculture farm had been developed. The motivation of this study was to solve the disputed problems of the community between two groups of farmers. The first group grew rice, but the other group worked on a marine shrimp aquaculture farm. The salt from marine shrimp aquaculture farm affected the environment as well as the rice growing according to the dehydration. In our study, the Direct Current method with the Finite difference technique was used to investigate the cross section of the ground of rice field and marine shrimp aquaculture farm. The conductivity profile of the ground was computed to show the profile of the salt and mineral under the ground. As mentioned by Lee and Ignetik (1994), salt concentration was strongly correlated with the conductivity of the ground. The iterative technique was conducted for constructing the conductivity model whose calculated responses were close to the observed values. A conductivity profile satisfying the data was constructed iteratively via successive perturbation of a starting model. Three examples were performed to investigate the ground structure. The first example was set to test our algorithm and perform the stability of our work. A set of synthesis potential data from the known ground structure location by using the forward problem was denoted. The second example used the potential data from the rice field. The third example used the data from marine shrimp aquaculture farm. For the last two examples, SYSCAL KID instrument to measure the potential data on the sites was used. The computational results of conductivity from the last two examples need to be compared to indicate that the government should allow the people to raise marine aquatic animals inland or support only at seashore.

Formulation of the problem

In this paper the method of Direct Current was used and the vector electric field $\vec{E}$ could be represented as the gradient of a scalar potential ϕ as

$$\vec{E} = -\nabla\phi,$$

where ∇ was the vector operator denoted by $\vec{i}\frac{\partial}{\partial x} + \vec{j}\frac{\partial}{\partial y} + \vec{k}\frac{\partial}{\partial z}$.

The divergence of the current density, $\vec{J}$, was zero, $\nabla \cdot \vec{J} = 0$ and it could be expressed in terms of the electric field using Ohm's law, $\vec{J} = \sigma\vec{E}$, as

$$\sigma\nabla\cdot\nabla\phi + (\nabla\phi)\cdot(\nabla\sigma) = 0, \qquad (1)$$

where σ was conductivity of the medium.

To investigate the cross section of the ground, the conductivity $\sigma(x,z)$ was denoted as a function of two variables x and z only. Thus, equation (1) became

$$\sigma\nabla^2\phi + \frac{\partial\phi}{\partial x}\frac{\partial\sigma}{\partial x} + \frac{\partial\phi}{\partial z}\frac{\partial\sigma}{\partial z} = 0. \qquad (2)$$

Equation (2) could be transformed by using finite difference method to get

$$\phi_{xz} \approx \frac{(\Delta z)^2\{\phi_x(4\sigma_{xz} + \sigma_x - \sigma_{\bar{x}}) + \phi_{\bar{x}}(4\sigma_{xz} - \sigma_x + \sigma_{\bar{x}})\}}{8\sigma_{xz}\{(\Delta x)^2 + (\Delta z)^2\}}$$

$$+ \frac{(\Delta x)^2\{\phi_z(4\sigma_{xz} + \sigma_z - \sigma_{\bar{z}}) + \phi_{\bar{z}}(4\sigma_{xz} - \sigma_z + \sigma_{\bar{z}})\}}{8\sigma_{xz}\{(\Delta x)^2 + (\Delta z)^2\}}, \qquad (3)$$

where $\phi_{xz} = \phi(x,z)$, $\sigma_{xz} = \sigma(x,z)$, $\phi_x = \phi(x+\Delta x, z)$, $\phi_z = \phi(x, z+\Delta z)$, $\phi_{\bar{x}} = \phi(x-\Delta x, z)$, $\phi_{\bar{z}} = \phi(x, z-\Delta z)$, $\sigma_x = \sigma(x+\Delta x, z)$, $\sigma_z = \sigma(x, z+\Delta z)$, $\sigma_{\bar{x}} = \sigma(x-\Delta x, z)$, $\sigma_{\bar{z}} = \sigma(x, z-\Delta z)$.

and Δx and Δz were the step of grid in the X and Z directions, respectively.

Inversion Process and Examples

To find the conductivity profile of the ground, $\sigma(x,z)$, the Quasi-Newton method in optimization technique was used to minimize the difference between the electric potential from calculation and real data. Equation (3) and the boundary conditions were applied to construct the matrix and compute the electrical potential by using Pentium IV 1.6 GHz PC computer. The iterative techniques were performed and given the solution converge rapidly. By using any initial guess of solutions, without lost of generality, the robustness of the process was very good compared to some related works such as the work done by Fullagar and Oldenburg (1984), Oldenburg (1979), Yooyuanyong (2000), Yooyuanyong and Siew (2000), and Yooyuanyong and Chumchob (2000). The conductivity profile of the starting model for the iterative process could be chosen, without lost of generality, to be the set of non-negative values which gave the process converge to the solution rapidly. In this section, three examples of inversion processes were presented. The first example, the potential data from a two layered earth model with constant resistivity profile as shown in Figure 1 were simulated. The potential data on the ground surface were generated by the forward problem to simulate the set of real data. The theoretical values were perturbed by superimposing a Gaussian relative error to the three per cent level. The associated errors could be regarded as realizations of normal random variables with zero means and variances, s_i^2 , $i=1, 2, 3, ..., m$. The boundary conditions for potential at the other three edges of Figure 1 were zeros.

Figure 2 showed the result of the resistivity profile from our iterative process. The model was started with the constant conductivity equals to 1 S/m. It could be seen that the result was close to the true model after using 5 iterations only.

In the second and third examples, the potential data were collected from the ground surface of rice field and marine shrimp aquaculture farm by using SYSCAL KID instrument at the following address, 12 Tumbon Bangluang, Aumphor Banglen, Nakhon Pathom Province as shown in Figure 3. The rice field as well as the marine shrimp aquaculture farm were used for more than 6 years. Both rice field and marine shrimp aquaculture farm were saturated with water as shown in Figure 3. As same as the previous example, the boundary conditions for the potential at very far from source were set to be zero according to the inverse square law of energy and distance between source and receiver.

The iterative technique performed quite well and the results were shown in Figure 4 and 5. Both figures showed the resistivity of the cross section of the ground. Figure 5 showed more black color

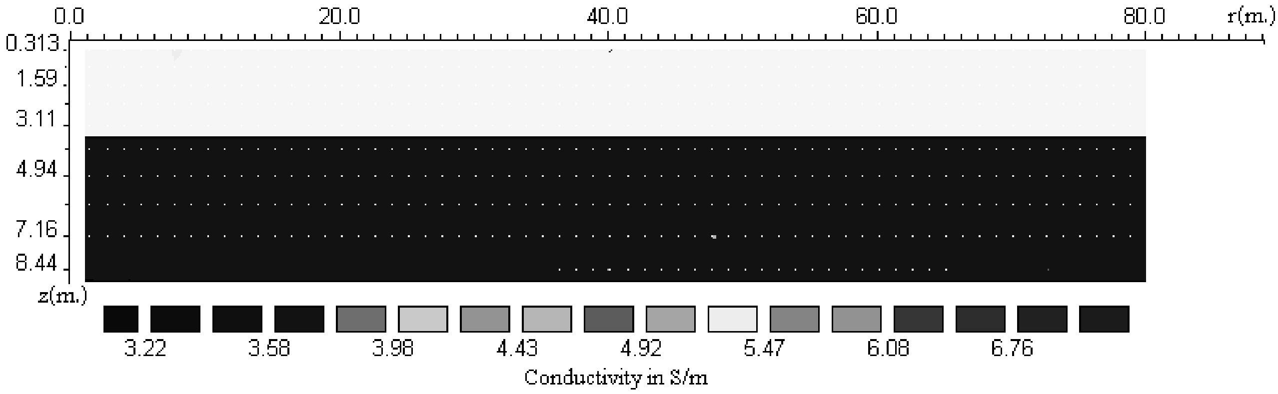

Figure 1 Cross section of a two layered model in XZ plane

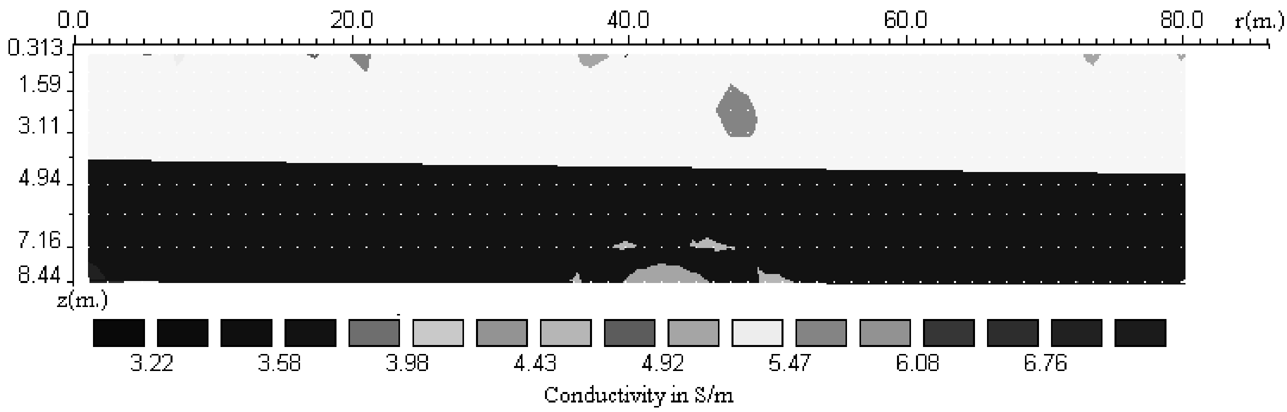

Figure 2 Cross section of the model which is calculated by using the synthesis data in XZ plane

Figure 3 Collection of potential data using SYSCAL KID at 12 Tumbon Bangluang Aumphor Banglen, Nakhon Pathom province

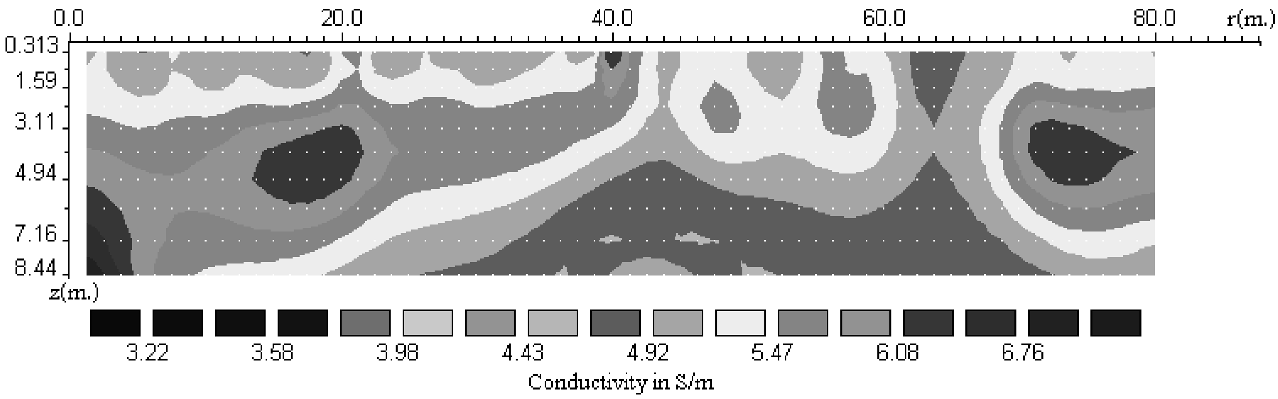

Figure 4 Cross section of rice field in XZ plane

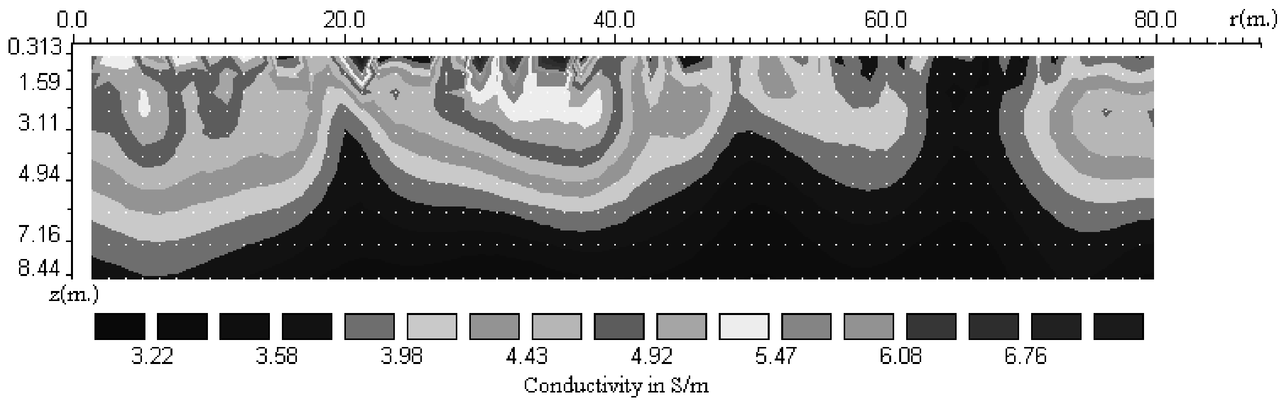

Figure 5 Cross section of marine shrimp aquaculture farm in XZ plane