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Comparison of Three Electrical Resistivity Arrays to Investigate Weak Zones in Soil, Along a Profile Southeast Baghdad City, Iraq

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Abstract:
The electrical resistivity method is one of the geophysical methods for detecting weak subsurface zone. The 2D resistivity data were used to compare three electrode configurations, Wenner, Dipole-dipole, and Schlumberger, to detect weak subsurface zones along a profile south of Baghdad near the Bismayah pumping station. The results show many zones of low resistivity that may be weak zones. A dipole-dipole array is a large number of measurements and is more sensitive than others. The Wenner-Schlumberger array has a depth also higher than other arrays. Wenner array has higher signal strength than other arrays. Because it is more sensitive to horizontal and vertical structures, the dipole-dipole array is the optimum for mapping subsurface weak zone.

Keywords: Comparison, Dipole-Dipole, Wenner, Schlumberger, Weak Zone

مقارنة ثلاث ترتيبات للمقاومية الكهربائية للتحري عن مناطق الضعف في التربة على طول مقطع جنوب شرق بغداد ، العراق

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الخلاصه
طريقة المقاومة الكهربائية هي من الطرق الجيوفيزيائية المستخدمة جيوفيزيائية لتعيين انطقة الضعف. تم استخدام القياسات المقاومة النوعية لغرض المقارنة بين الترتيبات المختلفة فنر، فنر شلمبرجير وثنائي القطب – ثنائي القطب لتعين مناطق الضعف على طول مقطع بالقرب من محطة ضخ بسماية. النتائج بينت عدد من المناطق قليلة المقاومة النوعية ربما تكون مناطق ضعف ترتيب ثنائي القطب –ثنائي القطب كان أكثر عدد قياسات وأكثر حساسية من بقية الترتيبات. ترتيب فنر–شلميرجر عمق أكثر من ترتيب فنر. ترتيب فنر هو الترتب الذي يمتلك اقوى إشارة من بقية الترتيبات. ترتيب ثنائي القطب–ثنائي القطب هو أفضل ترتب للكشف عن منطق الضعف التحت سطحية بسبب الحساسية العالية لتراكيب الافقية والعمودية.

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1. Introduction:

The resistivity method is one of the oldest geophysical survey techniques. Electrical surveys aim to determine the subsurface resistivity distribution by making measurements on the ground surface. From these measurements, the true resistivity of the subsurface can be estimated. Ground resistivity is related to various geological parameters such as mineral and fluid content, porosity, and degree of water saturation in the rock. Electrical resistivity surveys have been used for decades in hydrogeological, mining, geotechnical, environmental, and even hydrocarbon exploration [1]. The subsidence is a challenge in large cities. A downward movement of surface material produced by natural or man-made causes is known as subsidence [2]. Subsidence can cause many problems for the engineering structures such as roads and bridges. One of the geophysical methods used in the subsurface investigation is the electrical resistivity method, which calculates and identifies the distribution of subsurface resistivity by obtaining surface measurements and providing a subsurface picture of buried items [3]. The spacing between Current (C) and Potential(P) electrodes in a Dipole-dipole arrangement is set for each spacing and n-factor [4]. Because it has strong horizontal coverage yet is susceptible to telluric noise, it is used in shallow, weak zone detection [5]. Wenner arrays are mostly used to investigate lateral variation, while Schlumberger arrays are used to investigate the vertical variation in resistivity [6]. Karim et al., 2013 [7] Comprise the arrays of Wenner, dipole-dipole, and Schlumberger. They concluded that the Wenner- Schlumberger array has a greater median depth of examination and a smaller number of metrics than the Wenner array. Hameedawi1and Thabit (2017) [8] compared four electrode arrays (Dipole-Dipole, Wenner–Schlumberger, Schlumberger reciprocal, and Wenner) to examine their resolution and ability to delineate the layers in complex sedimentary deposits. The results showed that Wenner–Schlumberger's inverse models provide optimal results corresponding to the deep subsurface layers, and they show the best resolution with depth compared to the other arrays. Salman et al.,2019 [9] to identify the weak zone, dipole-dipole and pole-dipole arrangements were compared, with the dipole-dipole offering the best image of the weak zone. This research aims to show the advantages and disadvantages of different electrical resistivity arrays in finding weak zones in soil.

2. Applications and Discussions

The measurement was achieved at Bismaiya, southeastern Baghdad (Figure 1). A well drilled in the studied site for a depth of 30 m shows that the area consists of brown clay from 0.5 -18 m (Figure 2). From 18-30 m, the soil is represented by gray sand in the lower part. The water table at a depth of 1.9 m from the earth's surface, Figure -2. The surveyed area outside the station was carried on profile E-W north of the pumping station with a length of 100 meters. The measurements were carried out a SYSCAL Pro94 resistivity meter, recorded by three arrays at the same site. One hundred electrodes are employed in line, with an a-spacing of 1m and an n-factor of 4n (Figure 1). Measurement data processing used Res2dinv. Program. The total number of measurements for the D-D, W-Sch., and W arrays is 3291, 2238, and 1617, respectively. The information reveals areas of high resistance and low resistivity. This can be seen in Figures 3, 4, and 5. After six iterations, the RMS values for Wenner and Wenner-Schlumberger arrays are around 1.17 and 1.7 percent, respectively, and around 4 percent for D-D arrays presented in Figures 3, 4 and 5. The Schlumberger array (Figure 4) has a slightly different sensitivity pattern than the Wenner array, Figure 5. The inversion models for the study site show a wide range of subsurface resistivity for the Wenner array range from 0.5 to 40 ohm.m; dipole-dipole 0.5 and 45 ohm.m; and Wenner-Schlumberger resistivity values are between 0.5 and roughly 40 ohms.m. Low resistivity in the top and centre-left and a broader region in the Dipole-Dipole array distinguish the surveyed profile. This layer represents the clayey soil. Subsurface heterogeneity is caused by the presence of clay and silt, as well as different quantities of sand and other minerals. as shown in Figure 3. The presence of such roots is likely to result in certain oddities. The high resistivity Depending on whether the roots are dry or moist, the existence of such roots is likely to cause certain high resistivity anomalies. A very low resistivity (>0.5 ohms.m) anomaly was discovered in the profile line, as shown in Figures 3, 4, and 5, and this anomaly constituted a leakage area and can be interpreted as water leakage from the pipe.

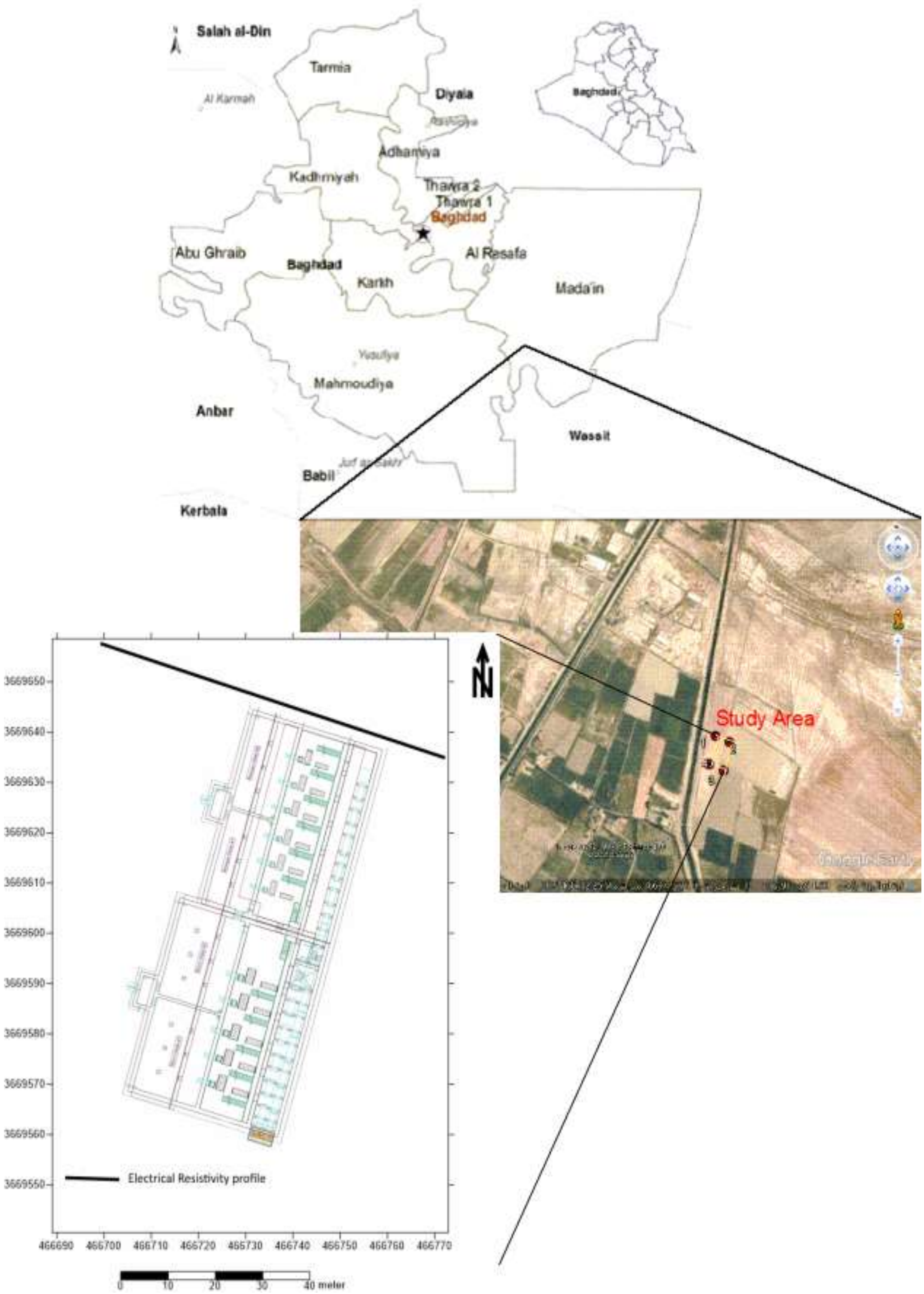

Figure 1: The location map of the study area shows the electrical resistivity Profile around the pumping station.

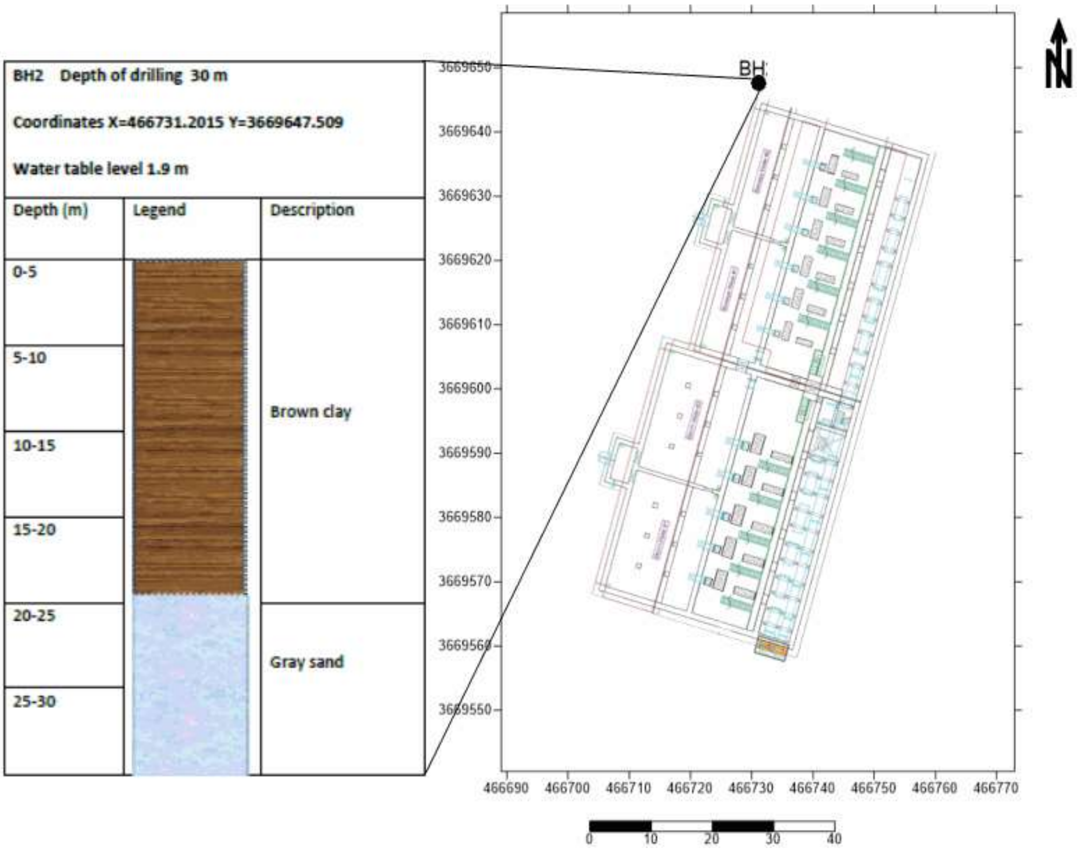

Figure 2: Lithological column for the existing Borehole within site.

The high resistivity values at the surface could be due to concrete buried in the soil, Figures 3, 4 and 5. The dipole-dipole array detects anomaly boundaries with greater precision, but it is susceptible to horizontal changes in resistivity, which reflects on the outcomes of many anomalies detected, Figure 4, and the effect of near-surface inhomogeneity.

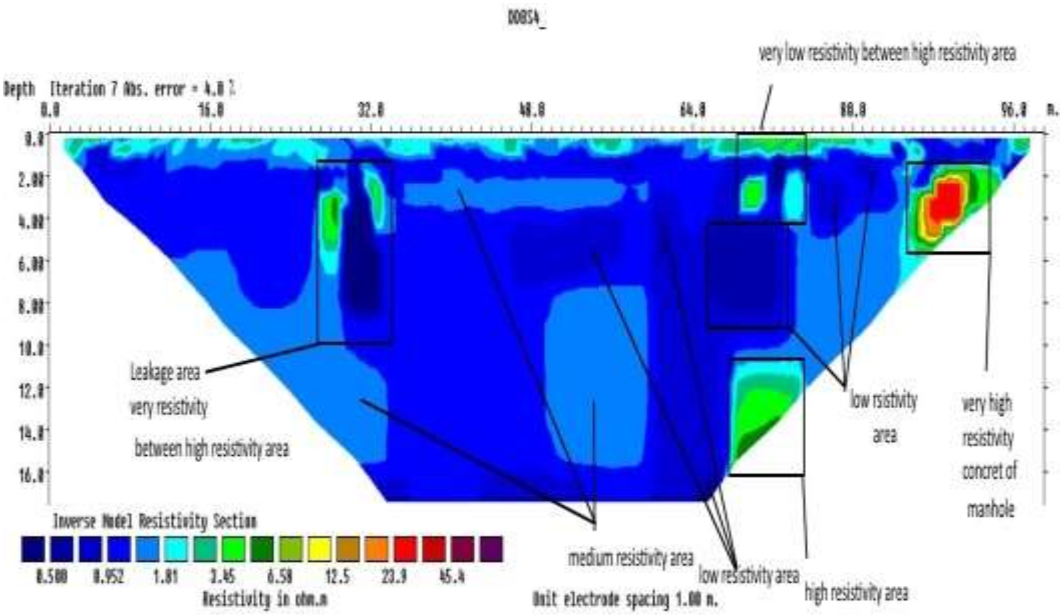

Figure 3: Field apparent resistivity inverted model of dipole-dipole array

Three elongated anomalies with positive anomaly up and bottom left profile, and another two at pole 32, represent the site's inhomogeneity and may refer to the amounts of sand. This anomaly only appears in the D-D array (Figure 3). The resolution of the Wenner array was reduced, and three anomalies developed, one at the bottom left and another at the 32 poles (Figure 5). Only two anomalies at pole 32 are visible on the Wenner-Schlumberger array, and the anomaly at the bottom left has a lower resolution (Figure 5).

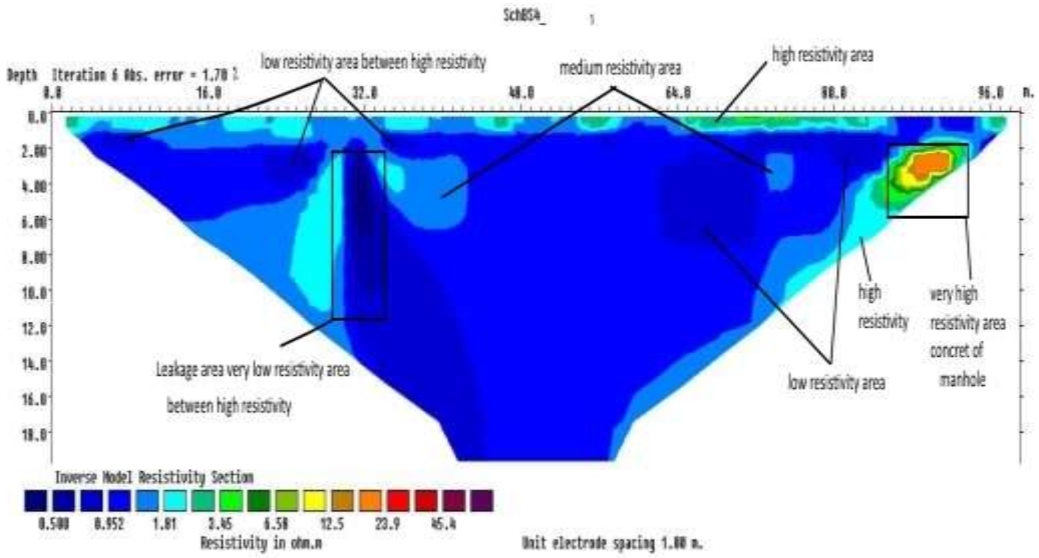

Figure 4: Field apparent resistivity inverted model of Wenner-Schlumberger array

The depth of arrays is different; the depth of Wenner and Schlumberger arrays is 18m, depth of the dipole-dipole array is 16m. The drop in resistivity to 1 ohm.m is interpreted as saturated soil, which the water well interprets as subsurface water leakage from the pipe.

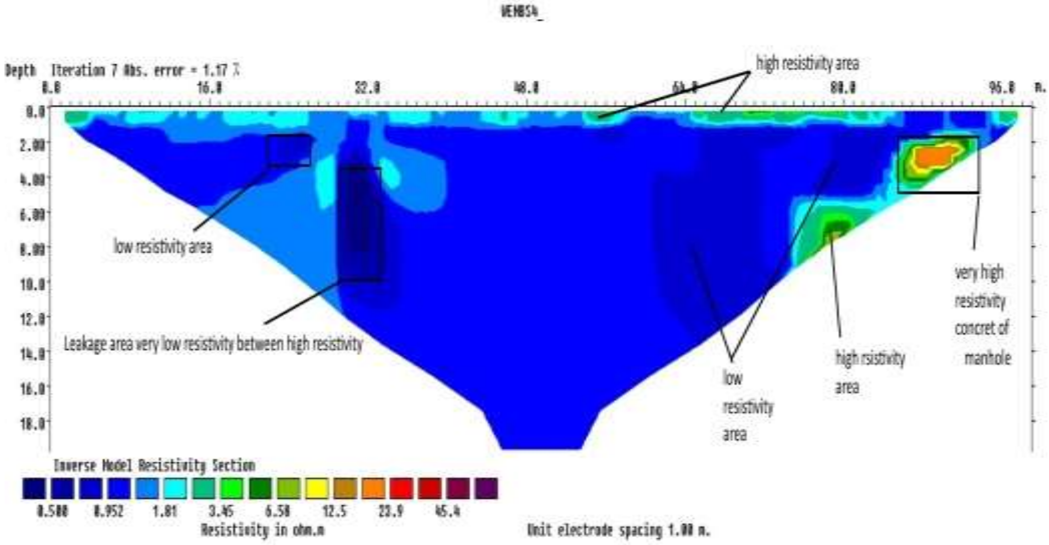

Figure 5: Field apparent resistivity inverted model of Wenner array.

5. Conclusions

The study compared different array of electrical resistivity methods can conclude the following:

1. The dipole-dipole array has the highest RMS and indicates a sharp decrease in resistivity.

2. The Wenner array has higher signal strength than other arrays.
3. The drop in resistivity to 1 ohm.m is interpreted as saturated soil, which the water will interpret as subsurface water leakage from the pipe.

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