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Detection of A Possible Subsurface Water Seepage Using 2D Electrical Resistivity Imaging Survey at a site in Al-Khwarizmi College of Engineering, University of Baghdad, Iraq

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Abstract

Unknown subsurface leaking water sources and possible subsurface seepage from a sewage tank in a garden at Al-Khawarizmi engineering college, University of Baghdad, were detected in this study. The 2D electrical resistivity imaging. The ERI survey is carried out along two lines, 60m and 50m long, with an electrode spacing of 1 m, forming a cross using the Wenner-Schlumberger array configuration. Line 1 is 60m, while line 2 is 50m. Soil samples were collected from line 1 at positions of electrode 34, which shows a high resistivity value, and electrode 55, which shows low resistivity, for laboratory analysis. Robust inversion and modelling processes showed relative change and high contrast in interpreted resistivities. Soil analysis showed a general homogeneity in mineral content and sediment type. Therefore, the relatively high contrast was related to variations in water content. The low resistivity was caused due to the water seepage from the sewage tank, which was precisely located.

Keywords: Electrical Resistivity Imaging; Seepage Investigation; Water content

الكشف عن التسرب تحت السطحي المحتمل للمياه باستخدام المسح الكهربائي ثنائي البعد في موقع كلية الهندسة الخوارزمي، جامعة بغداد، العراق

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الخلاصة:

تضمنت الدراسة الكشف عن مصدر غير معروف للمياه المتسربة تحت السطح واحتمال تسرب المياه من خزان مياه الصرف الصحي في حديقة في كلية الهندسة الخوارزمي بجامعة بغداد. اجري مسح ERI للتصوير بالمقاومة الكهربائية 2Dعلى طول خطين بطول 60 مترا و50 مترا مع تباعد أقطاب كهربائية يبلغ 1 متر يكون بشكل متقاطع (x) باستخدام ترتيب .Wenner-Schlumberger حيث كان المسار الاول 60 مترا بينما كان المسار الثاني 50 مترا فقط. أخذت عينات التربة من المسار 1 من القطبين 34 و55، اللذين يمثلان مقاومة عالية ومنخفضة على التوالي لغرض التحليل المختبري. أظهرت عملية الانعكاس والنمذجة

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القوية أن هناك تغييرا نسبيا وتباينا عاليا في المقاومات المفسرة. وأظهر تحليل التربة تجانس لكل من المحتوى المعدني ونوع الرواسب بحيث يرتبط التباين العالي في المقاومات المفسرة بمحتوى الماء الذي يأتي من تسرب المياه تحت سطح الأرض . في الختام تم التوصل الى معرفة مصادر التسرب المائي في منطقة الدراسة .

Introduction

Electrical Resistivity Tomography depicts the ground resistivity dispersion. It is necessary to have knowledge of resistivity values for various types of sub-surface substances as well as the geological features of the area based on a survey to transform the resistivity picture into the geological picture. The 2D electrical resistivity methodology aims to compare the 2D inverse model using two methods for interpretation utilizing the Standard Least-Squares Inversion and Robust Inversion Model Models. These models constrain the measurements and their resolution to show an image of the subsurface situation [1]. It is not always easy or simple to choose the right geophysical technique for detecting underlying structures, but it is essential in land-use management [2].

The electrical resistivity technique is regarded as one of the best geophysical survey techniques used in subsurface research studies because it provides a semi-true subsurface photo for underground structures while quickly calculating and determining the dispersion of subsurface resistivity by getting readings on the earth's surface [3].

Electrical resistivity has also been used to calculate the thickness of economic deposits of building materials like sand and gravel and to identify subsurface phenomena like gaping holes, valleys, and submerged canals. It is also widely used in environmental science and environmental protection [4]. The resistivity method was also applied to investigate the dam locations, subsurface storage sites, and other engineering applications [5,6].

The 2D resistivity imaging was used to identify and assess heterogeneity in the Kansas State University erosion function. It is found that the Wenner-Schlumberger array has higher resolved power in lateral and vertical resistivity variations, indicating more marked soil horizons with depth. At the same time, Wenner sections are confined to the uppermost soil layers [7]. The vertical electrical sounding (VES) and cross-vertical electrical sounding (CVES) techniques were used to investigate the homogeneity in an engineering site in south Baghdad City, and local heterogeneity in the soil was detected in some locations [8].
The 2D resistivity imaging technique was used to investigate the region east of Baghdad City to assess the geotechnical quality of the soil; the obtained results compared with the engineering test. Finally, the water seepage and its extent were evaluated, and the efficiency of the 2D resistivity imaging technique was confirmed [9].

Materials and Methods:

The location and the geology of the study site

The study area is a garden has approximately 700 m^2, located near Al-Khwarizmi Engineering College within the Campus of the University of Baghdad, Latitude 33°16' 8.53"N and Longitude 44°22' 23.09"E (Figure 1). The topsoil was divided into three main horizons by boreholes drilled within the University of Baghdad, the NCCL [10].
1. The fill zone: consists of brown silty clay or clayey silt, sand, and the presence of brick and concrete fragments.
2. Second zone: also known as the upper natural subsoil layers, this zone is moderate in stiffness and contains sand or gravel as well as brown silty clay or clayey silt.

3. The third zone, or lower natural subsurface layers, comprises gravel, clay lenses, silty clay lenses, and brown to gray sand. Compared to the second zone, this one has less cohesion.

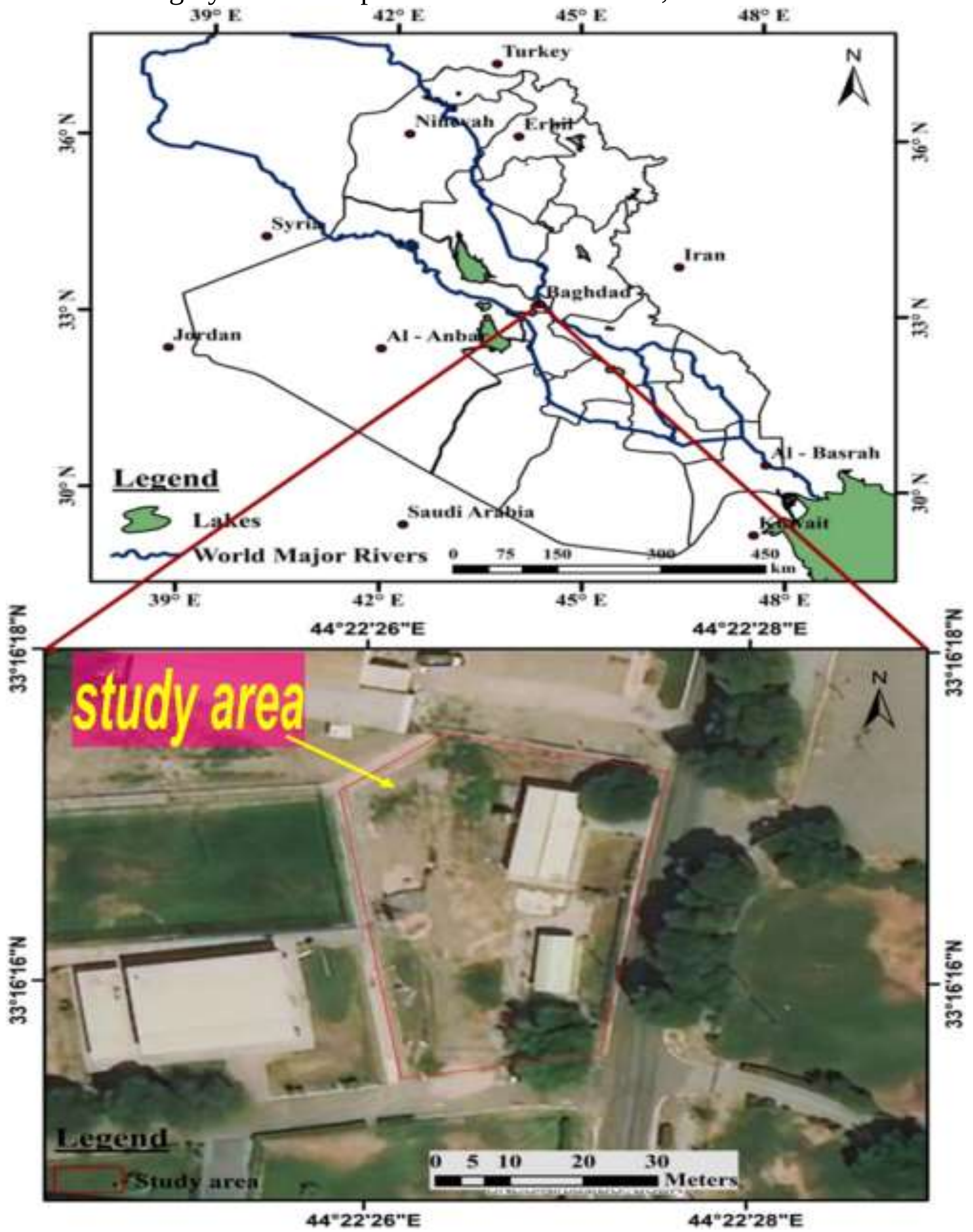

Figure 1: The location map of the study area.

Hydrogeology of the area:

Two water tables of the wells were investigated in the study area; their coordinates are determined in Table 1. The well -1 near the College of Engineering stadium has 35 above sea level. The distance between Well -1 and the Tigris River is around 450 m. The water level from the ground surface was measured using a sounder device and found to be 6.2 m, meaning that the water table elevation is 28.8 m above sea level (Figure 3). The well -2 is located near the park of the Engineering College with an elevation of 34 m above sea level (Figure 2). Well-2 is around 680 m away from the Tigris river. The water table level is 28.4 m above sea level. The water level of the Tigris River is 29 m above sea level, which means that the water level in the river controls the water in the study area.

Figure 2: Locations for well-1 and well-2 by Google Earth close to the study area by an aerial satellite image at the University of Baghdad

Table 1: coordinates for well-1 and well-2

Wells	Latitudes	Longetudes
Well-1	33°16'23.15"N	44°22'21.20"E
Well-2	33°16'18.87"N	44°22'30.56"E

Fieldwork:

Data acquisition and processing:

Fieldwork was conducted in March 2022. A 2D electrical resistivity imaging technique was used for data acquisition over two lines, as in Figure 3. Line -1 was 60m long with 1 m of electrode spacing, while line -2 was 50m with the same electrode spacing. The survey direction was from southwest to northeast in Line -1 and southeast to northwest in Line -2. A Wenner-Schlumberger configuration array was used for field data measurements. A Syscal Pro Switch 120 electrode computer-controlled system was used for data acquisition. The measurement sequence is designated to make n range from 1a–6a to reject theoretical measuring errors. All metal electrodes were calibrated and treated carefully to reduce the contact resistance between them and the ground surface to less than 1 kilo ohm to reduce noise level as much as possible and then reduce field measurement error. According to the used procedure, no bad data was found, and all measured data was considered.

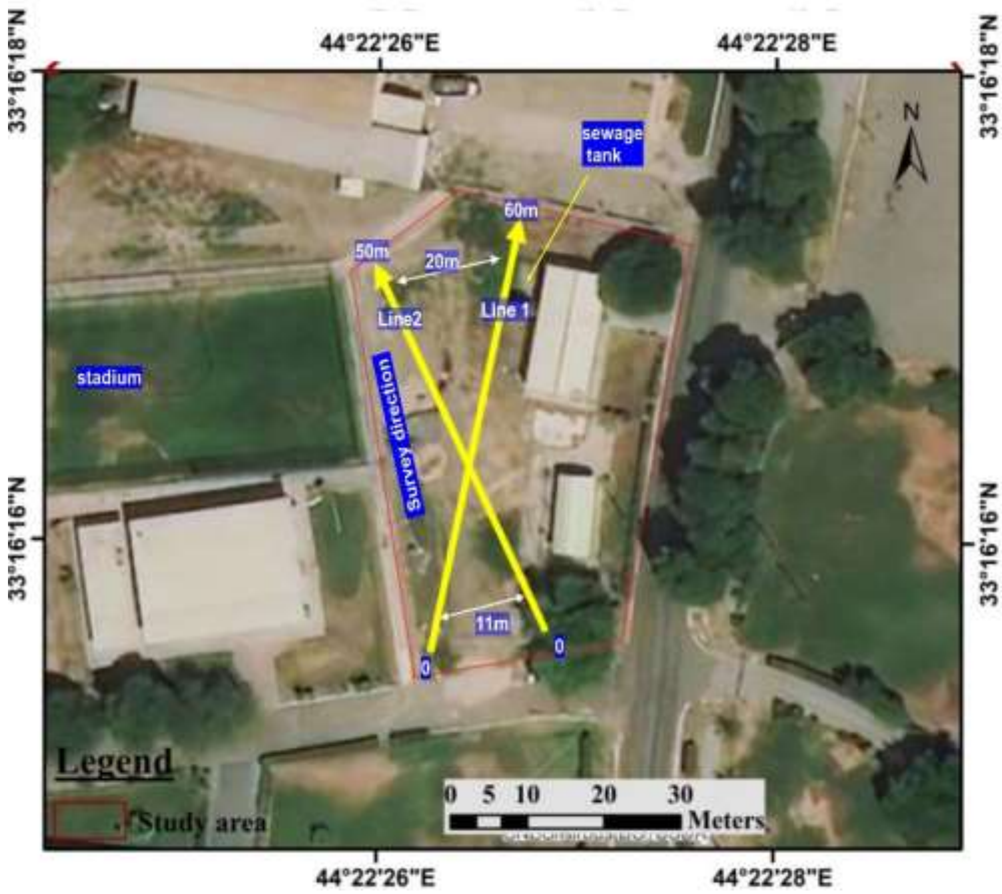

Figure 3: Location and direction of line -1 and line -2 in the study area.

The second stage of the fieldwork included taking soil samples from different depths (15–100 cm) from two electrodes location; electrode number 34 (high resistivity) and electrode 55 (low resistivity). The sampling stage aims to interpret the resistivity variation within the upper layer, 1m depth from the ground surface (Figure 4). The pH and TDS for the soil samples were measured, and chemical analyses were carried out according to the standard procedure of Folk [11].

Figure 4: Illustration of how to collect samples from the field for laboratory analysis. A) the distance between the sewage tank and the hole. (B) depth, the depth of the hole from which the samples were taken. (C) The measurement tape shows the distance accurately, which is about 2.50 m. (D) shows the Uger tool while taking samples**.**

The RES2DINV program, version 4.8.12, was used to process and interpret the 2D resistivity measurements [12]. The underlying layers' completed resistivity modelling was derived from measured apparent resistivity data obtained through a series of processes. The pseudo section is arranged to present raw data and also serves as a means for simple and quick data quality evaluation. The pseudo section will not detect minor errors in a data set, but it will detect untrue data points caused by, for example, instrumentation failures. Designers used the RES2DINV software to eliminate incorrect data before proceeding to the next step in creating an ultimate resistivity model.

Results and discussion:

1. laboratory analysis

The laboratory analyses results are presented in Table 2. The resistivity contrast for the same line are high and low, including moisture's effect. Electrode 55, away from the source sewage tank 2.50m, was depicted by water seeping and its effect on resistivity values as a low resistivity and the effect of compaction and dehydration as a high resistivity [13].
It is possible to obtain values of resistivity for high and low by using an option within the program Res2dinvx64. Put the mouse pointer inverted at any place within the model to take values.

Table 2: Displays the results of soil sample TDS and pH laboratory tests.

Samples	Line No.	Electrode	Depth (cm)	Resistivity (Ω·m)	PH	TDS (ppm)	Electro Conductivity EC µs/cm	Sand %	Silt %	Clay %
A	1	34	15	High (410)	7.7	145	270	11.2	47.9	40.9
B	1	34	100	High (400)	7.2	130	224	8.7	53.7	37.6
C	1	55	50	Low (15)	7.2	128	239	9.5	51.9	38. 6
D	1	55	100	Low (10)	7.1	178	300	12.4	52.1	35.5

2- 2D inversion and modelling

The 2D inverse results of the Wenner-Schlumberger configurations were shown using Robust Inversion Model Constraints for two lines considered (profiles). The inverse model represents the true image used during interpretation. The 2D resistivity model of the research site was based on the results of the 2D resistivity data being processed and transformed into resistivity modeling for interpretation. The values of TDS were not high because the area is fertile and the Tigris River near the study area acts as a filter for salts.

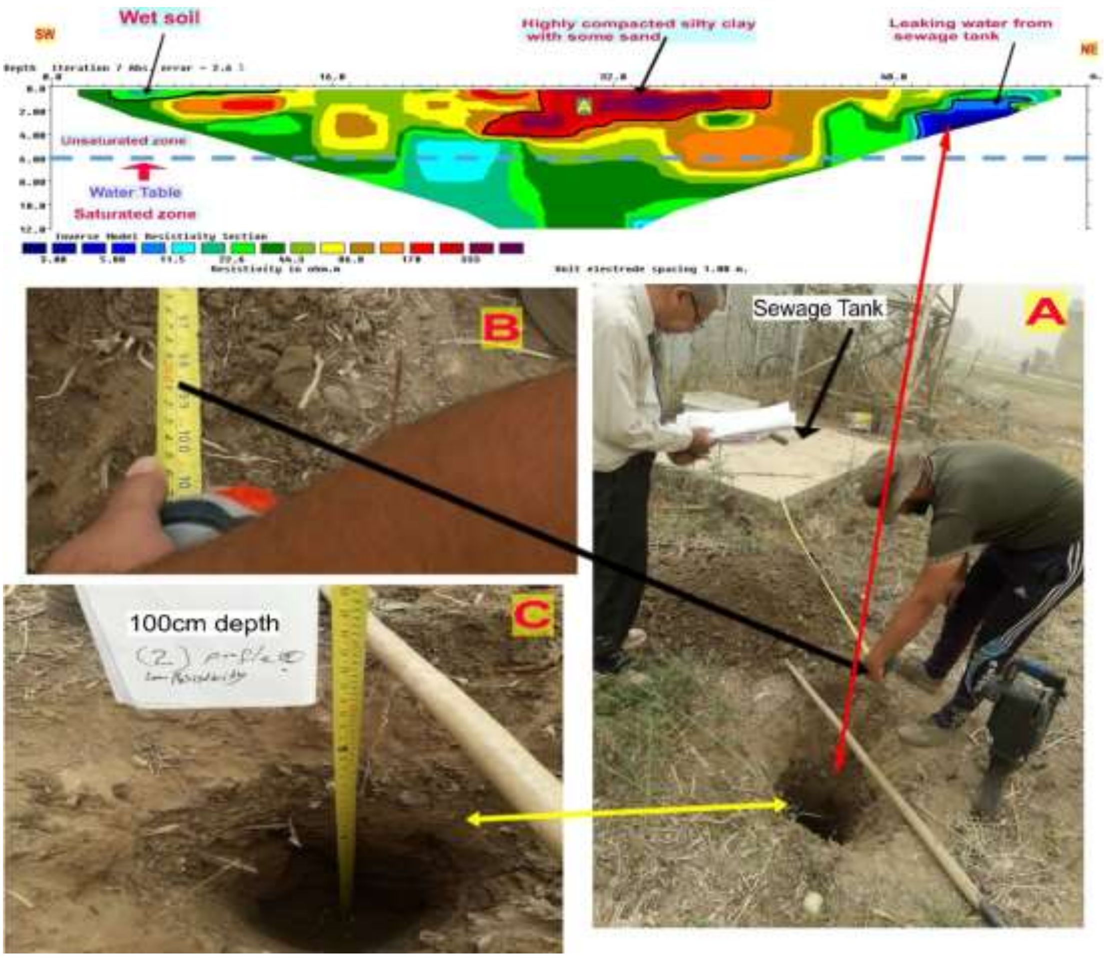

Figure 5. Inverted model of line -1. (A) Placement of sewage tank adjacent to the pit; (B) A tape meter measures distance; (C) The pit's depth is 100cm where samples were taken.

The laboratory results indicated that, despite the increase in the clay and silt (%) and the decrease in the sand (%), several factors influence the resistivity values that cause them to be high or low, and thus the occurrence of heterogeneity. Because the change in nature or sediment forms is also heterogeneous, these factors include water content (moisture), drought, compaction, and granular size.

The wet soil shows very clearly from electrode no.1 to electrode no.22, representing the intersection with electrode 19 in line 2 (Figure 5).
Zone (A) denotes an interbed of the area with the line-2 at 4 m deep, with a high resistivity (>333 ohms. m) within the unsaturated zone, and represents an expansion from electrode 22 to electrode 41.

It is found that seepage from a sewage tank located at a distance of 2.50m away from electrode 55 in line-1 reduces the resistivity values, and it may affect the foundation of the building.

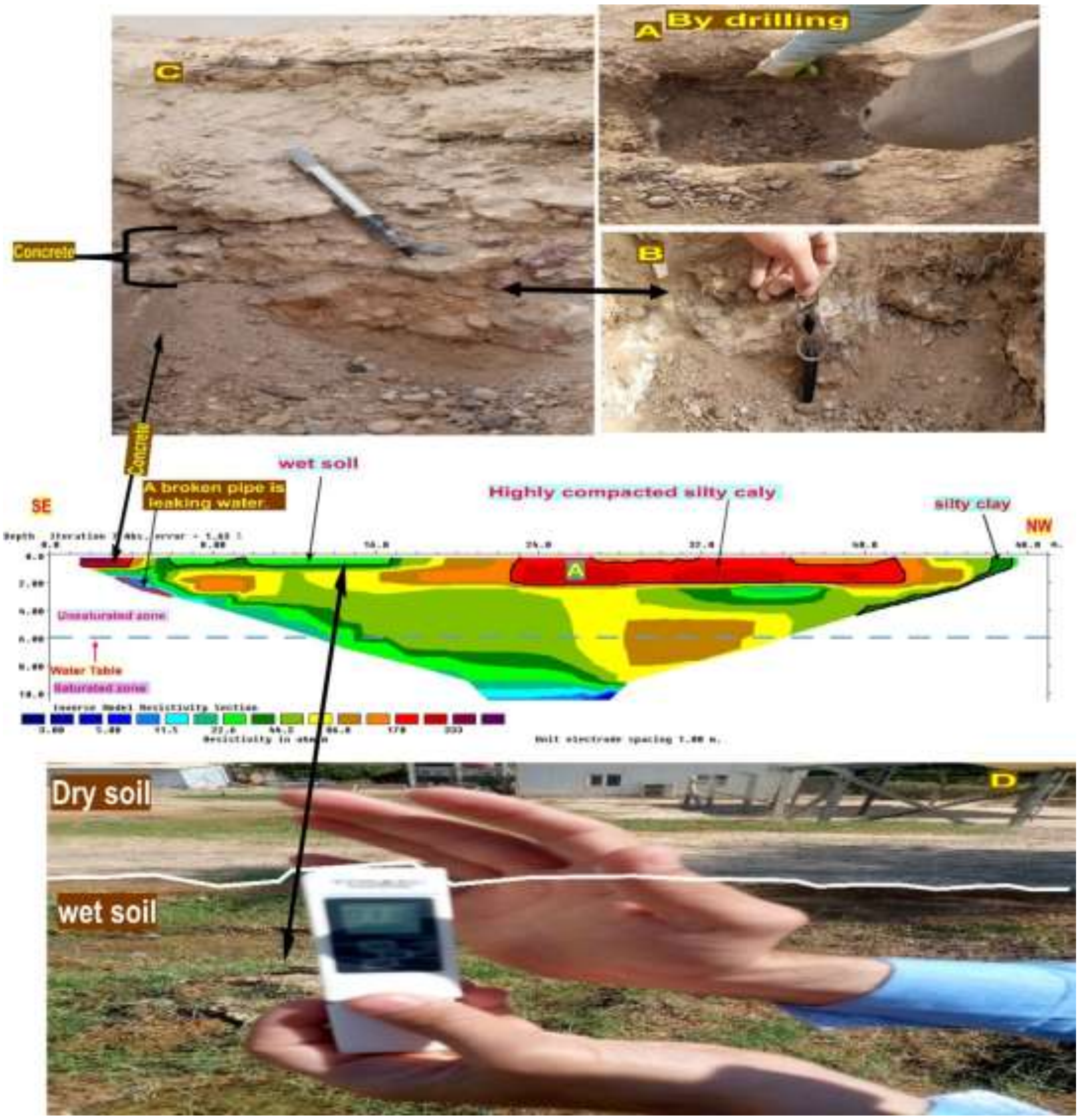

Figure 6: Inverted model of line -2. (A) pit drilled shows concrete as evidence of accurate fieldwork. (B) The same pit shows the thickness of the concrete. (C) shows the thickness of concrete from another side. (D) line 6 from the 8th electrode representing wet soil to the 19th electrode representing dry soil.

Regarding subsurface interpretation, as seen in Figure 6, concrete was discovered in excavation samples on the work site from electrodes 1 to 5, starting from 20 cm from the top surface. The area between electrodes 7 and 18 represents clay and some sand. As a result, it is a water-saturated area (wet soil). Then water samples were taken for laboratory testing to identify TDS and measure conductivity, which showed that TDS was 118 ppm and conductivity was 236 μS/cm.

Zone (A) represents the shared area between lines 1 and 2, which is highly compacted. It extends from electrode 23 to electrode 42 and, at a depth of up to 2 m within the unsaturated zone, it represents a strong near-surface inhomogeneity because of dehydration and compaction. Based on laboratory analysis, silt and clay were spread more than sand.

Conclusion:

The 2D electrical survey method was applied using the Wenner-Schlumberger array to investigate the causes of water seeping. The 2D electrical survey was carried out at the AL-Khwarizmi Engineering College at the University of Baghdad. It is found that the sewage tank and other water sources affect the study area and reduce the resistivity values. 3. Based on laboratory analysis for mineral soil analysis and soil nature analysis, the results show that the soil is homogeneous (same constituent but other factors produce inhomogeneity) at study sites and consists mainly of silty clay. Therefore, the variation in resistivity is attributed to moisture effects and other factors.

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