DETERMINATION OF UNDERGROUND WATER CONTAMINATION ZONE AND WATER TABLE BY SEISMIC REFRACTION METHOD AT AL-AZIZIYAH CITY WASIT PROVINCE - SOUTHREN IRAQ

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A R T I C L E   I N F O

A B S T R A C T

A seismic refraction investigation was carried out at Al-Aziziyah area for delineating water table and determining the velocity of different layers, as well as locating the contamination zones in under ground water which are resulted from agricultural activities. Nineteen seismic profiles were carried out in this study using ABEM TERRALOC seismic system. The length of each profile ranged from (33-115) m. with normal and reverse shooting. The recorded field data interpreted by delay time method using time distance curve as well as plus-minus method, mean-minus time method, ABC method and generalized reciprocal method. The velocities of the first layer range from (252-404) m/sec. and its average is (295.53) m/sec. while the velocities of the second layer ranges from (1335-1666) m/sec. and its average is (1494.21) m/sec. the velocities show no significant difference after interpreting by different methods. In this study the second layer represents the water table in the area with the depths range from (2.2- 5.5) m. Finally the contour map was drawn for the water table of the ground water, as well as a map differentiating the contaminated from non-contaminated zones.

Introduction:

Seismic refraction method has many applications in a variety of engineering problems and underground water investigation where information on the depth of water table is required. Despite the many successful uses of seismic methods there is still confusion in engineering practice as to the most appropriate stage of a site investigation program at which seismic refraction should be used (1). From the accumulated experience at a wide variety of sites in Iraq, the recommended sequence of investigation is field work followed by seismic refraction (2, 3, 4).

Seismic surveys provide sub-surface information over large areas at relatively low cost and locate critical areas for more detailed testing of contaminated ground water from seismic velocities at Al-Aziziyah area (5, 6, 7, 8).

If accurate predictions are to be made from seismic surveys, the field work must be carefully carried out and the results properly interpreted.

This paper aims to establish the basic features of the shallow seismic refraction method and its effective application in water table investigation and its contamination by recommended field procedures and interpretation techniques.

Basis of the method:

The seismic refraction method utilizes an impulsive source like hammer to produce an elastic waves which travel through the earth. Some of this energy in these waves is returned to the surface where the resulting ground vibrations are detected by geophones and recorded.

From these records, travel times of seismic waves between the impact point and a number of geophones a long earth's surface are measured. The velocities at

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which these waves travel through the subsurface are controlled by elasticity modules and density which generally vary both vertically and horizontally (9, 10, 11). The objectives of the refraction method are the determination of the velocities and depths of the layers and water tables as well as the contaminated area by hard water from p-wave velocity (12, 13).

TOPOGRAPHY:

The topography of an area is one of the very important factors in this kind of investigations, because any small change in the general ground surface along the seismic line may cause ambiguous seismic data (14). Therefore, we should take in our mind the topography corrections and must be accounted for in the interpretation.

The elevations of the shot points and geophones were placed mostly in the same level with few centimeters difference. The reason of chosen the same level is that the locations around Al-Aziziyah are placed on the high way and parallel to Tigris river. Also, inside Al-Aziziyah city the topography are almost horizontal for the profiles fig. (1).

For the above reasons, the quality of the data and subsequent interpretation are improved by avoiding dense vegetation for all stations that are parallel to Tigris River and Baghdad-Basrah high way.

Field procedure:

ABEM TERRALOC MARK-3 was used in this study which needs personal experience to design properly field program. Attention also given to such factors as geophone spread to get the target, nineteen profiles are chosen in the study area, and the length of the profiles in this study ranged between (33-115) m. and the spacing between geophones are (3-5) m. depending on the space in the study area. The kind of source is a hammer of (10) kg. weight, also enhancing of

data used to get good ratio of signal to noise. Shot points are located in both sides of the profiles for all stations.

MATERIAL CLASSIFICATION:

Seismic wave velocities in nature vary greatly (12, 15) and depend on such factors as hardness, degree of consolidation, weathering, jointing and water saturation. Table (1) shows a list of p-wave velocities for some common rocks and soil in Iraq. It can be seen from this table that there is a little chance of making a serious error when interpreting either low velocities as soil of Al-Aziziyah area, also actual lithological identification of rocks is not generally possible from seismic velocities but this, does not limit the usefulness of the seismic method as rock or soil with similar seismic velocities(1).
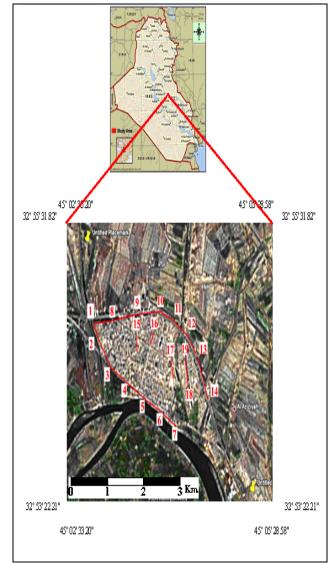

Fig. (1) Location map of Al-Aziziyah area showing all profiles.

In this study some of the profiles shows velocities of the second layer (water table) are larger than (1500) m/sec as at locations (1, 2, 8, 9, 10 and 11) table (2), Fig.(2) which shows the contaminated areas at these locations with hard water that are coming from agricultural activities north and east of the study area around Al-Aziziyah city Fig(1). As reaching Tigris River the velocities of the second layer which are indicating water tables decreases because of mixing fresh water of the.

Table (1) List of p-wave velocities for some common rocks and soils from various part of Iraq.

No	Location Name	P-wave (m/sec)	Rock type
1	Ejbail dam site (24)	1739	Compact red soil
2	Ejbail dam site (24)	2429	Limestone
3	Ejbail dam site (24)	1882	Calcium rich soil
4	Basrah (5, 6)	593	1st layer soil
5	Basrah (5, 6)	1462	2nd layer sand(W.T)
6	Hawija-Kerkuk (4, 8)	573	1st layer soil
7	Hawija-Kerkuk (4, 8)	1364	2nd layer silt (W.T)
8	Zubair power St. (*)	355	1st layer soil
9	Zubair power St.(*)	1491	2nd layer sand(W.T)
10	Adhaim dam site (2)	869	1st layer soil +sand
11	Adhaim dam site (2)	1569	2nd layer sand(W.T)
12	Al-Latifiya (3)	607	1st layer soil
13	Al-Latifiya (3)	1370	2nd layer sand(W.T)

* The velocities determined after researcher.

Table (2) Shows elevation above S.L., depth of water table from the surface, elevation of water table from S.L., and velocity of the layers.

Profile No.	Elevations Above Sea level (m)	Depths of water table from surface (m)	Elevations of water table above sea level (m)	Velocity of 1st layer m/sec	Velocity of 2nd layer m/sec
1	27	2.2	24.8	280	1535
2	27.6	3.5	24.1	310	1550
3	28	4.2	23.8	298	1520
4	27.5	4.1	23.4	404	1500
5	27	4.5	22.5	297	1335
6	26.4	3.7	22.7	273	1355
7	25.9	3.3	22.6	252	1424
8	28	3.4	24.6	270	1607
9	28	3.6	24.4	276	1563
10	28	3.7	24.3	275	1590
11	28	3.8	24.2	270	1666
12	28	3.7	24.3	319	1380
13	28	3.6	24.4	320	1408
14	28	3.4	24.6	292	1461
15	29	5.4	23.6	305	1515
16	28.6	4.7	23.9	284	1530
17	28.8	5.4	23.4	311	1490
18	28,8	5.0	23.8	292	1475
19	28,6	5.5	23.1	287	1486
Average velocity of the first layer = 295.53 m/sec					
Average velocity of the second layer = 1494.21 m/sec					

Tigris River with hard water that are coming from the above area.

Data corrections:

The first step of interpretation is to pick accurately the arrival times from seismograph. In shallow seismic refraction work in Al-Aziziyah area, the accuracy is not larger than (0.25) millisecond when using this type of equipment in the field. In picking travel times consideration should be given to the width and ambient noise.

Arrival times of all seismic traces in (19) profiles were picked and few of them are corrected which have some elevated areas, the corrections times are less than (2) milliseconds because the profiles are nearly horizontal.

Interpretation and results:
A: Travel time curve analysis:

Nineteen travel time curves were drawn to determine the velocities and depths of the layers in each profile. Average velocities and depths were taken for normal and reverse shooting for all profiles, because there is no significant difference between the results in the study area, Fig. (4) shows the time distance curve for one of the profiles.

The methods of interpretation used are delay time method (9, 11), plus – minus method (16, 17), mean minus time method (18), generalized reciprocal method

(19, 20, 21, 22), and ABC method (18) for velocities and depths determination, the average of all results are shown in table (1). The average velocities of the first and second layer are (295.53) and (1494.21) m/sec. respectively. The ranges of the depths from the surface are between (2.2-5.5) m. These depths are documented from boreholes that are drilled by civilians inside Al-Aziziyah area at some places.

B: Contour map of the ground water:

For each profile the elevations were determined by GPS above sea level, as well as the depths of water table which are the depths of second layer from seismic method, so the subtraction represent the elevations above sea level, these values are distributed on the map (23), then the contour lines were drawn Fig.(3).
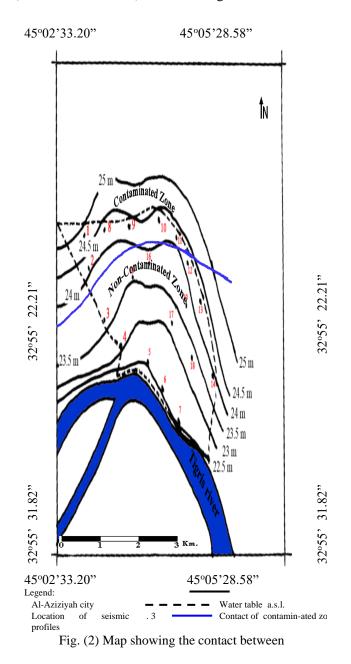
Discussion:

The study area shows that the northern part of Al-Aziziyah area are contaminated by agricultural activities most of them are from fertilizers and sabkha, the area shows also the direction of ground water flow from north and northeast to south and southwest (to the direction of Tigris River), which is considered as natural discharge area and controls the movement of the ground water flow direction as shown in Fig. (2).
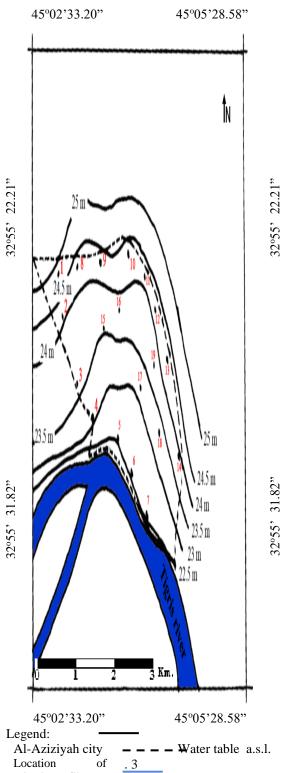
Conclusions:

1-Seismic refraction method is very effective in searching for ground water resources by using p-waves, their values in the study area and in southern Iraq ranges from (1450-1500) m/sec for fresh water to about more than (1600) m/sec for moderately hard water..

2- The velocities of first layer are ranging from (252-404) m/sec., and the velocities of the second layer which represents ground water level are ranging from (1335-1666) m/sec.
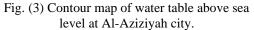
3- The average velocities of the first layer is (295.53) m/sec. and for the second layer is (1494.21) m/sec. which represent the velocity of ground water level.

4- The depths of the water table in the study area are ranging from (2.2-5.5) m. depending on the position of the seismic profiles.

5-The elevations of water tables above sea level are ranging from (22.5-24.8) m.

6- The directions of ground water flow are from north and northeast to the south and southwest area.

7- The contamination area is concentr-ated on profiles (1, 2, 8, 9, 10 and 11) because of agricultural activities.

Fig. (2) Map showing the contact between

contaminated and non-contaminated zone.

45°02'33.20"   45°05'28.58"

45°02'33.20"   45°05'28.58"

Legend:
Al-Aziziyah city   — — — Water table a.s.l.
Location   of   . 3
seismic profiles
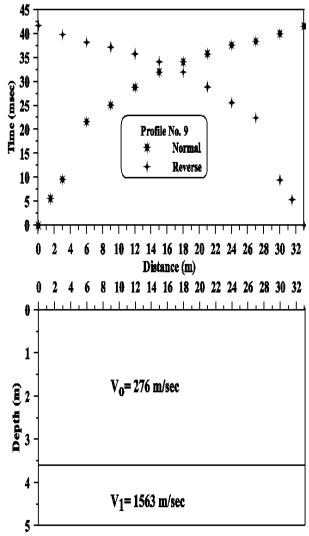Fig. (3) Contour map of water table above sea
level at Al-Aziziyah city.

Fig. (4) The travel time curve for the profile No. (9) in
the study area.

References:

1. Greenhalgh,S,A., and Whitely ,R,J.,(1997). Effective application of the seismic refraction method to high way engineering projects .Australian Road Research. Vol.7:No.1: P. 3-20.

2. Khorshid, S.Z. (1994). Geotechnical evaluation of Adhaim dam area by using geophysical method. Unpublished Ph.D. thesis. Dept. of geology, Univ. of Baghdad, 183P (in Arabic).

3. Khorshid, S.Z. (1984). An investigation of refracted P and S waves in sediments. Unpublished M. Sc. thesis. Dept. of geology, Univ. of Baghdad, 177P (in Arabic).

4. Ishaq, A.S. (1998). Delineation of shallow geological structures and water table depth in El-Hawija area by using seismic refraction method. Unpublished M.Sc. thesis. Dept. of geology, Univ. of Baghdad, 115P (in Arabic).

5. Khorshid, S.Z., Al-Khesan, E.H. and Al-Khashan, A. Z. (2006). Basrah Journal of science.Vol.24:No.2: P 27-37.

6. Safa Al-din, T., Hijab, B. R., Khorshid, S.Z. and Hassan, N.A. (2004). Shear wave velocities and elasto-dynamic properties of soil at Basrah children hospital. Unpublished report. Scientific consulting Bureau, College of Science, University of Baghdad.

7. Alsinawi, S.A., Khorshid, S.Z., Hamdi, F.A.I. (1990). Application of compressional and shear wave velocities in solving geotechnical problems associated with gypsiferous sediments in central Iraq. Iraqi J. Science. Vol.31:No.31: P.590-610.

8. Al-Rawi, F.R., Ishaq, A.S., Khorshid., S.Z. (2002).Delineation of shallow geologic structures and depth of water table in Al-Hawija area by using seismic refraction method. Faculty of Science Bulletin. Sana'a University. Vol.15:No.1:P.950110.

9. Telford, W.M., Geldart, L.P., Sheriff, R.E. (1990). Applied Geophysics. Cambridge University Press. 2nd edition. Transferred to digital printing (2004). 770P.

10. Dobrin, M.B. (1976). Introduction to Geophysical Prospecting. 3rd edition. McGraw Hill Pub.Co. New York.630P.

11. Sharma, P.V. (1986). Geophysical Methods in Geology. 2nd edition. Elsevier New York. 440P.

12. Milsom, J. (2003). Field Geophysics. John Wiley and Sons Ltd. 232P.

13. Dugiud, J.O. (1968). Refraction determination of water table depth and alluvium thickness. Geophysics. Vol.33:No.3: P.481-488.

14. Mota, L. (1954). Determination of dips and depths of geological layers by seismic refraction method. Geophysics. Vol.19: P.242-252.

15. Press, F. (1966). Seismic velocities. Hand book of physical constants. Geol. Soc. Am. Inc. Medr. 97:P.195-218.

16. Hagedooren, J.G. (1959). The plus minus method of interpreting seismic refraction sections. Geophysical prospecting. Vol.7: P.158-182

17. Van Overmeeran, R.A. (1987). The plus minus method for rapid field processing by portable computer of seismic refraction data in multi-layer ground water studies. First Break. Vol.5:No.3: P.83-94.

18. Sjogren, B. (1984).Shallow refraction seismics. Chapman and Hall. London. 270P.

19. Palmer, D. (1981). An introduction to the generalized reciprocal method of seismic refraction interpretation. Geophysics. Vol. 46:No.11:P.1508-1518.

20. Kilty, T.K., Norris, R., Maclomore, W.R., Hennon, K.P. and Euge, K. (1986). Seismic refraction at Horse Dam: An application of the generalized reciprocal method. Geophysics. Vol.51:No.2:P.266-275.

21. Hartherly, P.J. and Neville, M.J. (1986).Experience with generalized reciprocal method of seismic refraction interpretation for shallow engineering site investigation. Geophysics. Vol.51:No.2:P.255-265.

22.Wright, C. (1996). A note on the computation of the offset distance X Y in the generalized reciprocal method of seismic refraction interpretation. Geophysical prospecting. Vol.44:P.41-53.

23. Lankistone, R.W. (1989). The seismic refraction method: Available tool for mapping shallow target into the 1990's.Geophysics.Vol.54:No.12:P,1535-1542.

24. Safa Al-din, T., Hijab, B.R., Tamr Agha, M.Y. (2002). Geological and geotechnical investigation of the Ejbail dam site. Scientific Consultant Bureau. College of Science. University of Baghdad. Vol.3:Part.1:357P. Unpublished report.

تحديد مناسيب المياه الجوفية ومناطق تلوثها بالطريقة الزلزالية الانكسارية في ناحية العزيزية- محافظة واسط -جنوب العراق

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الخلاصة:

تم اجراء مسح زلزالي انكساري في منطقة العزيزية لتحديد عمق المياه الجوفية ودراسة سرع الموجات الزلزالية للطبقات فضلا عن تحديد مناطق التلوث الحاصل في المياه الجوفية نتيجة الفعاليات الزراعية. شمل البحث مسح (19) مساراً بأطوال تتراوح من (33-115) متراً بأسلوب المسح الاعتيادي والمعكوس. تم تفسير المعطيات الحقلية لهذا المسح بطريقة زمن التأخير (Delay Time) بعد رسم منحنيات المسافة والزمن فضلاً عن اساليب التفسير الاخرى (طريقة الموجب والسالب (Plus-Minus)، وطريقة Mean-minus Time، وطريقة ABC، وطريقة(Generalized Reciprocal Method) حيث تراوحت سرعة الطبقة الاولى من (252-404)م/ ثا وان معدلها (295.53)م/ثا، بينما تتراوح سرعة الطبقة الثانية من (1335-1666) م/ثا ومعدلها(1494.21) م/ثا، علما بان ليس هناك فروقات جوهرية في تفسيرالمعلومات بالطرائق المختلفة. ان حدود الطبقة الثانية تمثل مستوى المياه الجوفية وقد تم حساب أعماقها في المنطقة وكانت تتراوح من (2.2-5.5)م وتم رسم خارطه كونتوريه لمستوى المياه الجوفيه وكذلك تم رسم خارطة لتحديد مناطق المياه الجوفية الملوثة عن غير الملوثة.