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Determination of the Locations of Ground Water Table Anomalies by the Ring and Central Point Method Study of Three Areas in Iraq

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ABSTRACT

The groundwater table is observed in three areas in Iraq. Many wells are used to construct the ground water table maps in these areas. These maps are reflecting the irregularity in the water table.

The observed values of groundwater table are converted to a regular grid of water table points, with different spacing interval from area to another. The regional groundwater table is calculated, using the ring and central point method, in each observation point. The residual (local) anomalies in the ground water table values for the grid points are obtained by the subtracting of the regional (average values) of ground water table from the observed values. The griding of water table and the calculations of regional and residual anomalies are done using QBASIC computer program build for this purpose. The regional ground water table and residual anomaly of groundwater table are mapped, the regional maps show the main water table level in the studied areas. The residual maps show many positive and negative anomalies of groundwater table. These maps reflect that the positive anomalies related to the leakage of water from the subsurface pipelines and drainage channels in the studied areas, while the negative anomaly related to the high pumping or discharge rate. This method can be used to determine the locations of leakage from pipelines and drainage channels.

استخدام طريقة الحلقة والنقطة المركزية لتحديد مواقع الشذوذ في مناسيب المياه الجوفية دراسة ثلاث مواقع في العراق

الملخص

تم في هذه الدراسة قياس مناسيب المياه الجوفية في ثلاث مواقع في العراق ، رصدت مناسيب المياه الجوفية في عدد من الابار في كل موقع. ، ثم رسمت خرائط مناسيب المياه الجوفية فيها وتبين وجود عوامل غير طبيعية مؤثرة على المنسوب. مناسيب المياه الجوفية التي تم قياسها تم تحويلها الى شبكة منتظمة من القيم بواسطة الحاسوب وبمسافة بين نقاط الشبكة تختلف من موقع الى اخر. تم حساب المنسوب الاقليمي للمياه الجوفية في كل نقطة باستخدام طريقة الحلقة والنقطة المركزية. قيم الشواذ المحلية في منسوب المياه الجوفية حسبت من الفرق بين القراءة المرصودة حقليا في النقطة المعنية وبين

المنسوب الاقليمي في تلك النقطة. رسمت الخريطة الكنتورية للمنسوب الاقليمي للمياه الجوفية ومـــن ثـــم رسمت خريطة الشواذ المحلية والتي بينت وجود شواذ موجبة وسالبة. عزيت الشواذ الموجبة الى تسرب المياه من الانابيب تحت السطحية ومن قنوات المجاري، بينما عزيت الشواذ السالبة الى الضـــخ الجـــائر للمياه الجوفية لاغراض الري او الى التصريف العالي للمياه الجوفية في بعض المناطق. ســـاعد تحديـــد مواقع الشواذ الموجبة في تحديد مواقع تسرب المياه من الانابيب ومن ثم معالجتها.

INTRODUCTION

The variation in the groundwater table levels caused the variation in the hydrogeological condition. Where the ground water table is shallow, within the upper soil zone, water may change the soil properties or dissolve some minerals of the soil such as gypsum or calcite. The problem is very serious, especially in the conditions of constructing building foundations over a soil that rich with gypsum or calcite associated with fluctuated hydrogeological environment. This variation in the hydrogeological conditions caused many environmental problems such as a rise of ground water table, cavities and weak zones in the soil under the foundations of structures.

The studied areas contain many industrial and urban establishments, and most of the buildings in these establishments show evidences on differential settlements in the walls, corrosion of foundations and buildings materials, because the leakage of water from the subsurface pipelines and drainage channels. The present study aims to investigate the relation between these problems and the condition of ground water table variation with time in the studied areas and determine the sites of the leakage by the suggested method.

FIELD WORK

The fieldwork concerning the hydrogeological study started at August-2001, involving ground water data collections from 24 wells in the 1st area and 19 wells in the 2nd one. While the data of levels of ground water table of the 3rd area are taken from Farman (1996), figure (1).

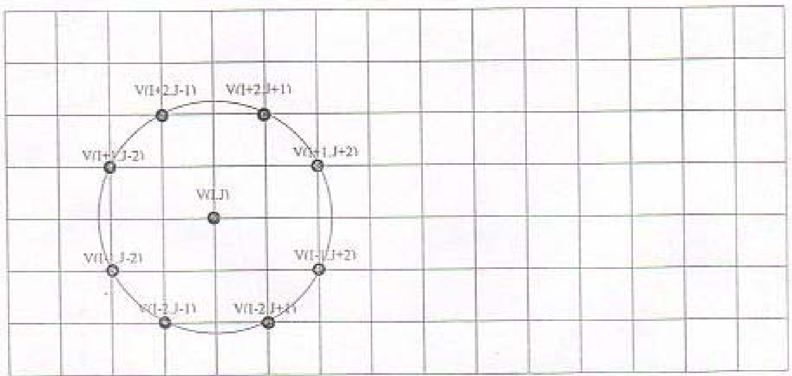
The levels of water table were measured in these wells using leveling instrument type KERN, the measurements were done in the 1st area relative to the reference point of 191 m.a.s.l. While in the 2nd area the measurements were done relative to the reference point of 115 m.a.s.l nearby the meteorological office of Baiji.

THE RING AND CENTRAL POINT METHOD

The statistical method of ring and central point that suggested by Griffin is used to determine the regional trend and residual anomalies of the areal distribution of the observed gravity data (Dobrin, 1976). This analytical method of determining residual gravity makes it possible for isolates anomalies with out such a great reliance upon the exercise of judgment in carrying out the separations (Dobrin, 1976).

In this method the observed data of many points over the area are digitized as a regular grid with constant spacing between one point to another. For any point on the grid, assume this point is a center of circle, there the regional value represents the average of the values of eight points on the circumference of the circle that surrounding the mentioned point figure (2). The residual anomaly represents the difference between the

Fig.1: location map of the studied areas.



V(I,J) = represent the value of ground water table in the central point

$V_{reg}(I,J)$= regional value of the same point

$=((V(I-2,J-1)+ V(I-2,J+1)+ V(I-1,J-2)+ V(I-1,J+2)+ V(I+1,J-2)+ V(I+1,J+2)+ V(I+2,J-1)+ V(I+2,J+1))/8$

$V_{res}(I,J)$= residual value of the same point = $V(I,J)- V_{reg}(I,J)$

Fig.2: the calculations of regeional values and residual anomalies of ground water table on the regular grid by ring and center point method.

observed and the regional values. This study is the first attempt to apply the method to determine the anomalies of the ground water table in the three studied areas. The residual (local) variations in the ground water table values for the grid points are obtained by the subtracting of the regional (average values) of ground water table from the observed values.

The principal problem of this method of this technique is in the choice of a radius, the spacing of sampling points around the circumference is arbitrary, it should be large enough to ensure that the circle will lie entirely outside the anomaly but not large enough to include irregularities from other sources. It is not always possible to meet these conditions. So that it is important to select the optimum radius if the results are to be reliable (Dobrin, 1976).

Many radiuses were experimented to separate the regional ground water table in the studied areas, the optimum radius is $2S\sqrt{5}$.

When S = space between point to another in the grid.

= 10m, 125m, 250m for the three areas respectively

HYDROGEOLOGICAL SYSTEM DESCRIPTION

Area I:

This Area of North Fertilizers Company is located at about 240km towards the north of Baghdad and about 30km to the north of Baiji. The hydrogeological investigation reflects that there are two main aquifers in the studied area, the upper aquifer "shallow" is unconfined, while the deeper one is confined.

The depth of confined aquifer is more than 15m and covered by claystone bed that separates this aquifer from upper unconfined one. The confined is consisting of layers of older alluvium deposits that are separated from Injanah Formation by a clay bed. The unconfined aquifer is represented by the alluvium deposits (Quaternary) which consist of sandy gravel or silty sand with gravel. The surface of the area is mainly composed of gypcrete soils which ranges in thickness from 0.5-1m (GEOSURV, 1999). The aquifer is bounded from the bottom by impermeable clayey layer (NCCL, 1997). The salinity of water in the confined aquifer is more than 6000ppm. While, the salinity of ground water in the unconfined one is less than that of confined one, and ranged between 2900 ppm to 4100ppm (Rashid et al., 1998). Dilution may occur in the location due to the leakage from fresh water pipe lines that effect the regional ground water table.

The elevation of ground water table was observed in 24 points (wells). The observed elevations used to draw the contour map of ground water table. The flow lines were drawn perpendicular to the groundwater equipotential lines. The groundwater at the area of study were found to flow from the area of local recharges (North Fertilizers Company) to the surrounded area, figure (3).

Area II:

Baiji City is located at about 210km towards the north of Baghdad. The hydrogeological information reveal that there are two main aquifers in the studied area, the upper aquifer "shallow" is unconfined, while the deeper is the confined one.

The depth of confined aquifer is more than 12-14 m and covered by claystone bed that separates this aquifer from upper unconfined one. The confined aquifer is represented by the layers of older alluvium deposits that are separated from Injanah

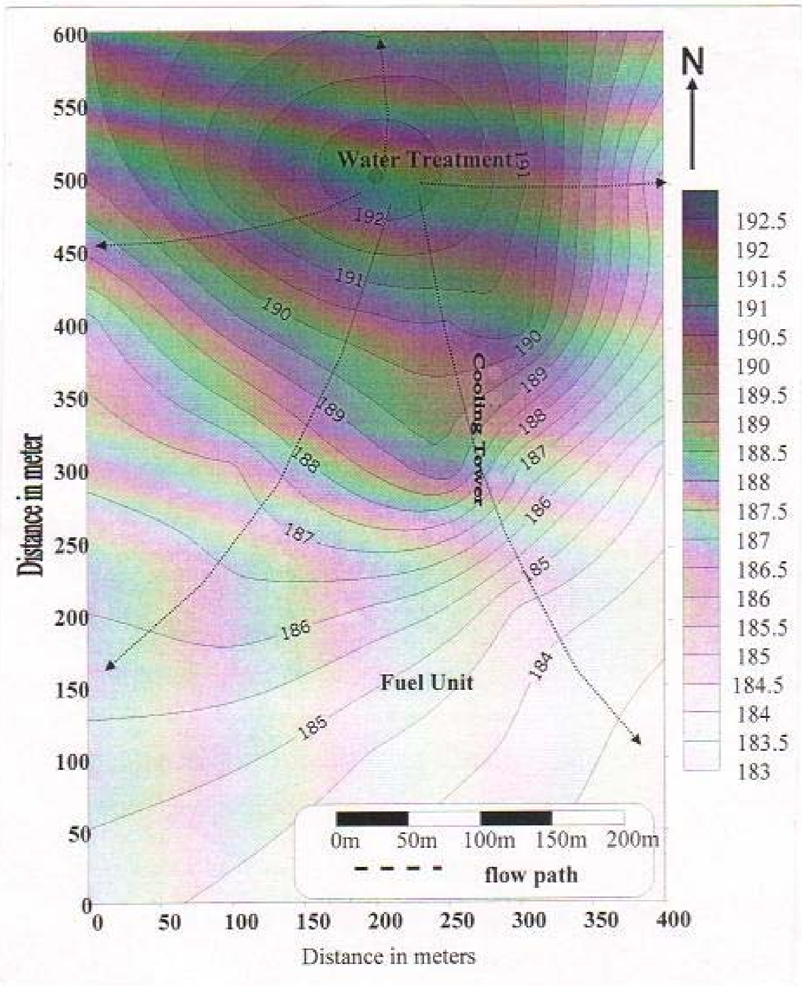


Fig.3: grond water table and flow direction of ground water in the 1st area.

Formation by a clay bed. The salinity of water in this aquifer reached more than 5000ppm (Kadhim, 1996).

The unconfined aquifer is represented by the alluvium deposits (Quaternary), which consist from the bottom to the top by a sequence of clay, sand clay, clayey gravel and soil. The aquifer is bounded from the bottom by impermeable clayey layer. The salinity of ground water in this aquifer is less than that of confined one, and ranged between 1100 ppm to 4000 ppm.

The elevation of ground water table was observed in 19 points (wells). The observed elevations used to draw the contour map of ground water table figure (4).

Area III:

The area of Karbala City and the surroundings areas lie between Euphrates River on the east and Lake Razzaza to the west, (i.e.) between 43° 50' - 44° 09' E and latitude 32° 31' - 32° 43' N. figure (1). Karbala City is located in the center of the area, the Hussaynia irrigation canal passes through the northern part of the city. The city is sustained from rising of ground water especially in the old center due to the urban recharge of the city (Farman, 1996).

The elevation of ground water table was observed in 20 wells and pizometers that drilled by (FCSDIP, 1995). The observed elevations in these wells and pizometers done by (Farman, 1996) used to draw the contour map of ground water table figure (5).

Morphologically, the elevation of the plateau between Lake Razzaza and Karbala City reach to 70 meters a.s.l in southwestern part and it slopes gently to the north and northeast directions. Karbala City locates in a flat plain of 40 meter a.s.l.

Geologically, the area covered by the outcrops of Injana (U. Miocene) and Dibdiba (L. Miocene- Pleistocene) formations. Injana formation crops out along the shore of Razzaza Lake, it consists of continental red, brown and gray marls, silt, siltstone, sandstone. The thickness of the formation in the studied area is ranged between 90 to 120 meters. The Dibdiba formation covers many parts of the studied area, it consists of clays, silt layers, fine to medium grained sand with local lenticular bodies of sometimes hard cemented coarse sand and gravel, the granular and fibrous gypsum are recognized as cementing materials. Its thickness ranges between 15-20m near Karbala City and 12-15m near Razzaza Lake. Beneath Karbala City, the lithology is generally similar to geological conditions of the area and consists of layers of sand and calcareous silt. These layers contained gypsum that is partly cemented. The saturated thickness of the unconfined aquifer was assumed to be 30m. The major sources of ground water recharge are Razzaza Lake, Hussaynia irrigation canal, and domestic use water of Karbala City. Ground water is drained by networks of drainage system, main drains in the area are; Karbala drain, Razzaza drain, Emam Mansoor drain, Hussaynia drain, Emam Noah and many others (Farman, 1996).

The main regional structure in the study area is the swell situated between Falluja and Karbala (Buday and Jassim, 1987).

All the morphological, structural, geological and hydrogeological conditions in the studied areas above are effected to the regional ground water elevation but cannot be cause local (narrow) anomalies in the ground water table.

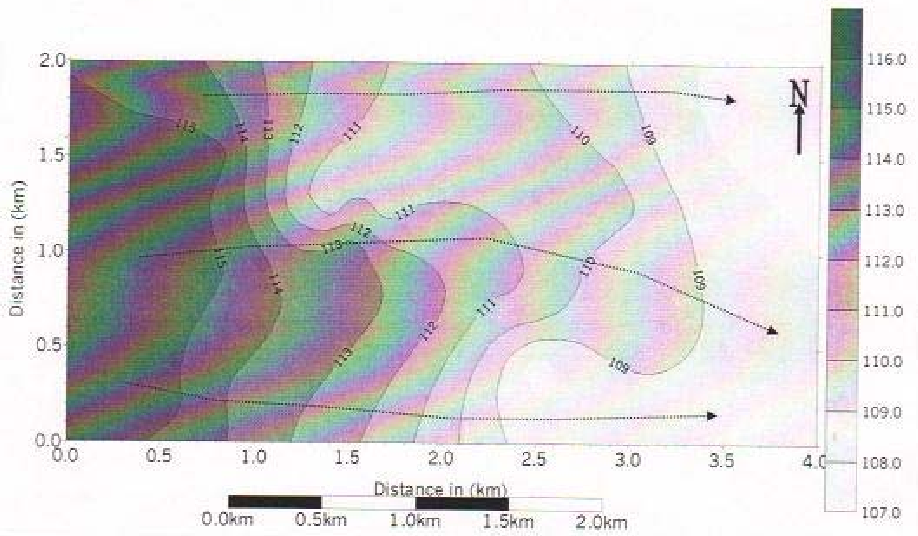


Fig. 4: Grond water table in the 2nd area.

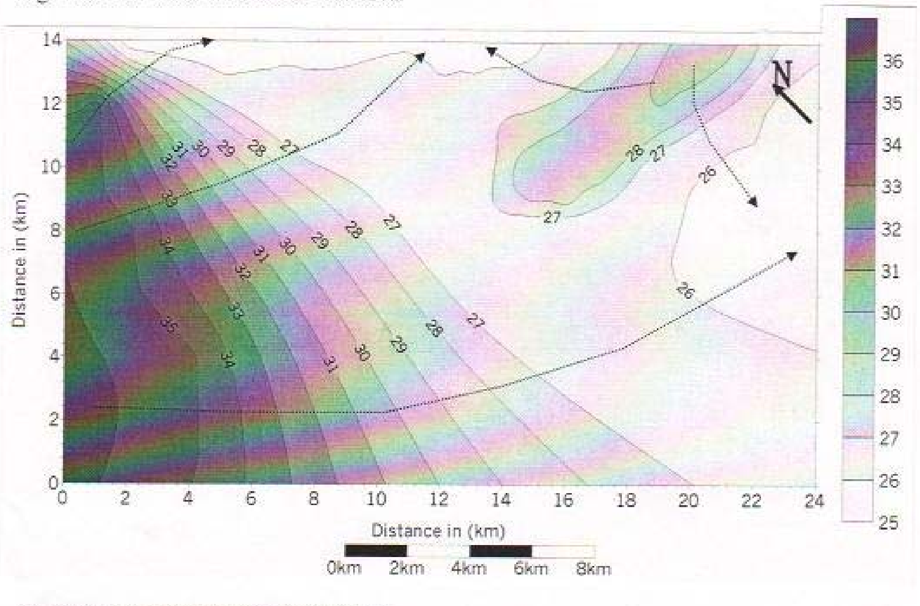


Fig. 5: Grond water table in the 3rd area.

DETERMINATION OF THE LOCAL ANOMALIES IN GROUND WATER TABLE

The ground water table maps of the three areas are digitized using the computer program with grid spacing 10,125, 250meters for the 1st, 2nd and 3rd areas respectively. Then the statistical method of ring and central point is applied. The radius of the circle used for obtaining the regional ground water table is $20\sqrt{5}$m for the 1st case, $250\sqrt{5}$m for the 2nd, and $500\sqrt{5}$m for the 3rd one. The resultant regional ground water table is plotted with respect to the sea level as in figures 6a, 7a and 8a for the three areas respectively.

In the 1st area the regional ground water table generally decreased from the north to the southeast of the area. The hydraulic gradient increased from the middle of the area to the southeast due to the local recharge of ground water in the north and middle parts of the area by the leakage of water from the subsurface pipelines of cooling and demineralized water units of the industrial establishment, figure (6a). In the 2nd area the regional ground water table generally decreased from the west to the east of the area with different hydraulic gradient due to the local recharge of ground water from the leakage of water from subsurface pipe lines, figure (7a). In the 3rd area the regional ground water table generally reached 36 m.a.s.l. in the recharge area nearby Razzaza Lake in the western and southwestern of the area, while the ground water table decreased to 26 m.a.s.l. in the discharge area nearby the network of drainage system in the eastern and northeastern parts of the area. The hydraulic gradient also fluctuated from site to another due to the local recharge, especially in the northern middle part due to the effect of local recharge of the leakage from the subsurface pipelines and irrigation channels and the discharge in the network of drain system, figure (8a).

The residual (local) variation in ground water table relative to the regional one is plotted in figures 6b, 7b and 8b for the three areas respectively.

In the first area, there are three major positive anomalies, which do not exceed 1.5 meter. These anomalies reflect the rising of ground water because the effect of the leakage from subsurface water pipelines and channels of demineralized water, ammonia and cooling water units in the sites I, II, and III respectively, Figure (6b).

In the second area, the figure (7b) shows the local positive anomalies reached more than 3 meters in the site (I) along the western and southwestern parts of the area, due to the leakage from the network of drinking water pipelines and drainage channels. In the middle of the area (site II) there is a positive anomaly reached 1.2 meter due to the same reasons above. Between the two positive anomalies in the site (III), there is negative anomaly reached -0.8 meter due to the high efficiency of the drainage system along this anomaly.

In the 3rd area the main local anomaly in the sites (I) reached to 1.2 meters due to the leakage of water pipelines and Irrigation canal in Karbala City. While the negative anomaly in the sites (II) reached -1.2 meters nearby the network of drainage system and the sites of high pumping for irrigation purposes in the agricultural areas.

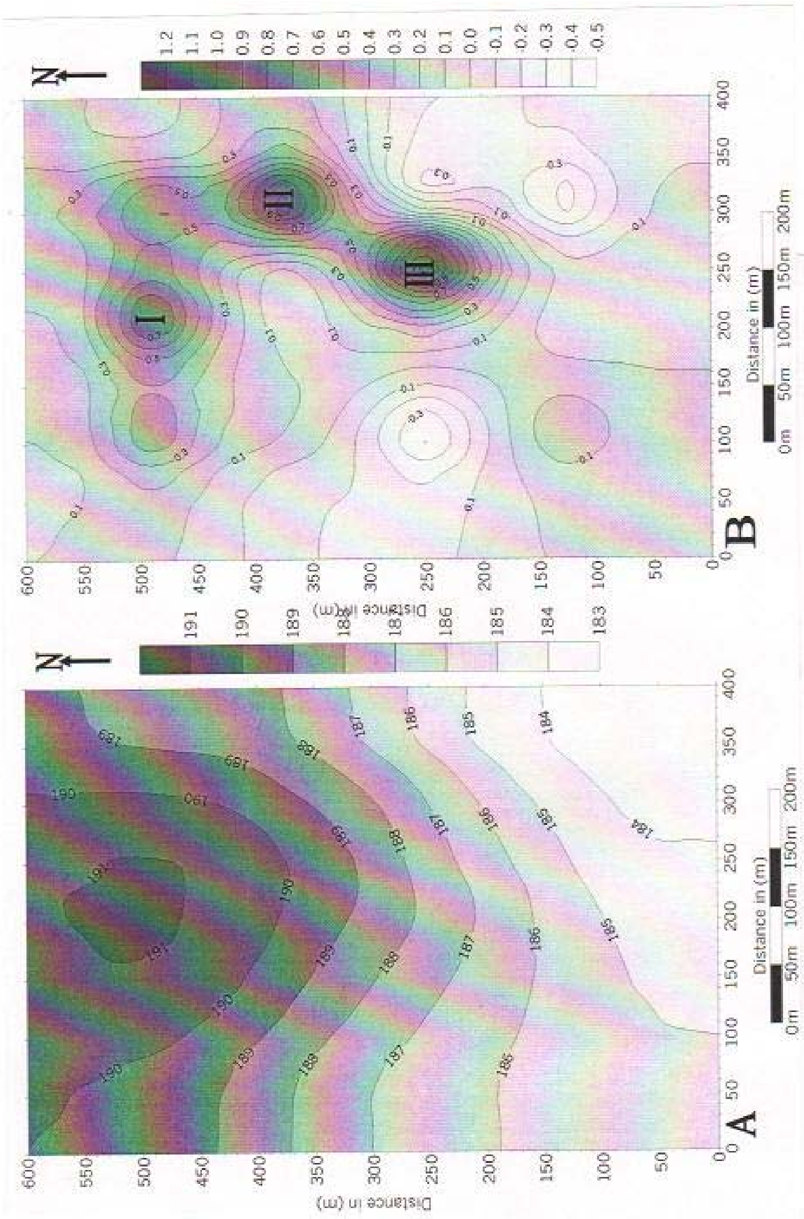


Fig. 6: A.Regional ground water table in meters a. s. l. in the area of 1st site.
B.Residual ground water table anomaly in meters in the area of 1st site.

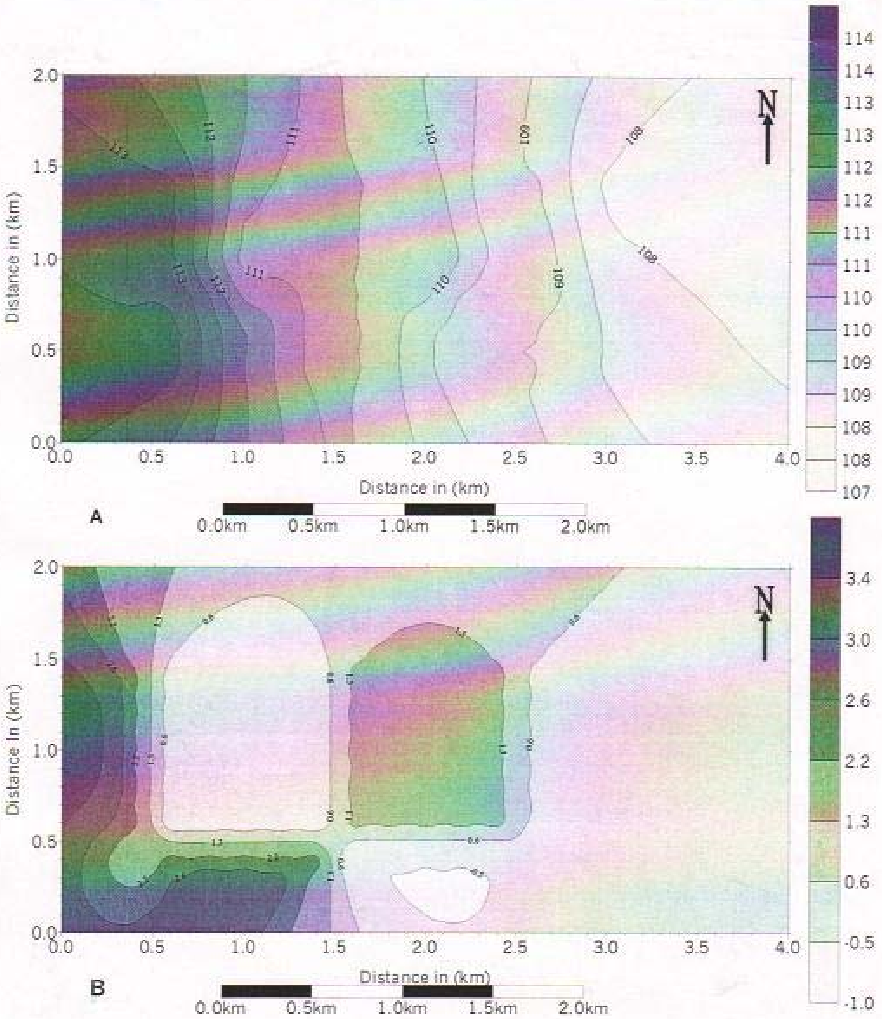


Fig. 7: A.Reginoal water table in meters a.s.l.in the area of 2nd site.
B. Residul ground water table anomaly in meters in the area of 2nd site.

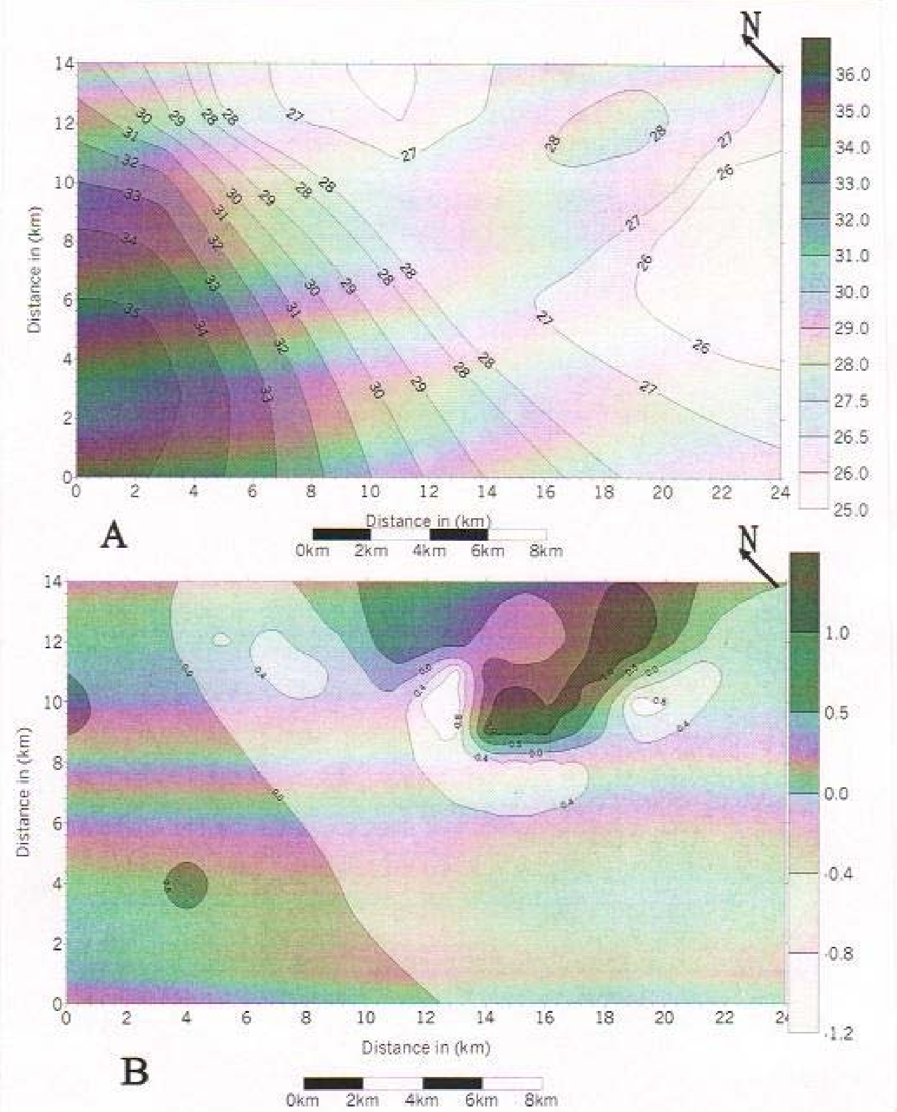


Fig. 8: A. Regional ground water table in meters a.s.l. in the area of 3rd site.
B. residual ground water table anomaly in meters in the area of 3rd site.

The rising or lowering of ground water in the three locations is due to the human activities. These activities are either high pumping rate from the ground water for irrigation, or the high efficiency of drainage system which caused a negative local ground water anomaly, or due to the leakage of surface water from pipelines or drainage channels that caused positive anomaly. The variation in the ground water table represents hazardous problem to the foundations of constructions, especially in the industrial establishments. The most hazardous problem is the fluctuation of the ground water table, which caused washing of soluble particles such as gypsum from the soil and weakening the soil under the foundations.

Locations of positive groundwater level anomalies also can be considered marking the locations of leakage of pipelines that needed to be treated.

CONCLUSIONS

1. It is concluded from the present study that the ring and central point method is useful for determining the regional trends of ground water table surface.
2. The ring and central point method is suitable for defining local ground water table anomalies, which are related to the human activity in the studied locations.
3. The positive local ground water table anomalies reflect an area of recharge. In the present study the source of water is the leakage from the subsurface pipelines.
4. The negative local ground water table anomalies occurred due to the high pumping rates from the wells for irrigation purposes or due to the high efficiency of drainage system.
5. Rising of ground water table to the level of foundations of buildings of industrial establishments is very hazardous problem. So, the annually measurements of ground water table in the establishments locations represent good method to control the safety parameters for the buildings of the studied locations.

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