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Assessment of Groundwater Potential in Karayanchavadi Region, Chennai

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Abstract

The present work is aimed at assessing the groundwater potential in a region of Chennai, where agriculture is the main livelihood of rural and urban people and the groundwater is the main source of irrigation and drinking. It is noted that in Tamil Nadu, there is evidently much dependence on groundwater due to scarce surface water. The hydro-geological features such as sub-soil structure, rock formation, lithology and location of water play a crucial role in determining the potential of water storage in groundwater reservoirs. In the present study the assessment of groundwater potential for Karayanchavadi region is carried out and safe yield is ascertained. It has been inferred from the study that the magnitude of annual rainfall and groundwater potential has a decreasing trend. The estimated safe groundwater potential for the study area is 859.59ha-m and the net safe yield after subtracting the overdraft and evaporation loss is 773.63ha-m.

Keywords: Groundwater, Karayanchavadi, Safe Yield, Rainfall, Water level fluctuations.

Introduction

Groundwater is precious and the most widely distributed resource of the earth. It is considered as an important segment of the hydrologic cycle as well as it amounts to one third of world’s fresh water reserves. Utilization of this resource can be traced back to Mohenjo-Daro civilization about 3000B.C, where brick-lined wells were constructed for storage and supply of drinking water. (KC.Patra, 2002). Groundwater abstraction is increasing day by day due to its increasing demand for various purposes. (Yesodha et al 2010).

Groundwater was the major source of irrigation prior to the introduction of canal irrigation system. In the last few decades, there has been a tremendous increase in the demand for freshwater due to rapid growth of population and the accelerated pace of industrialization. (Dhanasekar.K et al 2012). Exploitation of groundwater has increased greatly, particularly for agricultural purpose, because large parts of the country receive little rainfall due to frequent failures of monsoon and variable flow of surface water sources like rivers, lakes and artificial basins which clearly indicate the growing pressure on ground water resources.

The ground water resource quantification is often considered critical and also the non-availability of a single comprehensive technique leads to difficult situation in estimating accurate ground water assessment. (Mohan.S et al). Also, the hydrogeological parameters help us to determine the performance of the aquifer**.** Added to this, an important factor is the length of data considered for predicting the groundwater potential. In this study, the groundwater potential is determined by groundwater fluctuation method (GEC Committee, 2009).

Study Area

The Study area is Karayanchavadi in Chennai,Tamilnadu,India. The bearing of the study area is 13°03’00" N and 80°05’59" E, and it covers an area of about 80 sq. km. It is located in the downstream of Chembarambakkam Lake, which is a major source of agricultural and domestic water supply for Chennai. The location map of study area is shown in Figure 1. Chennai district enjoys a tropical climate with the mean annual temperature of 24.3 to 32.9°C.

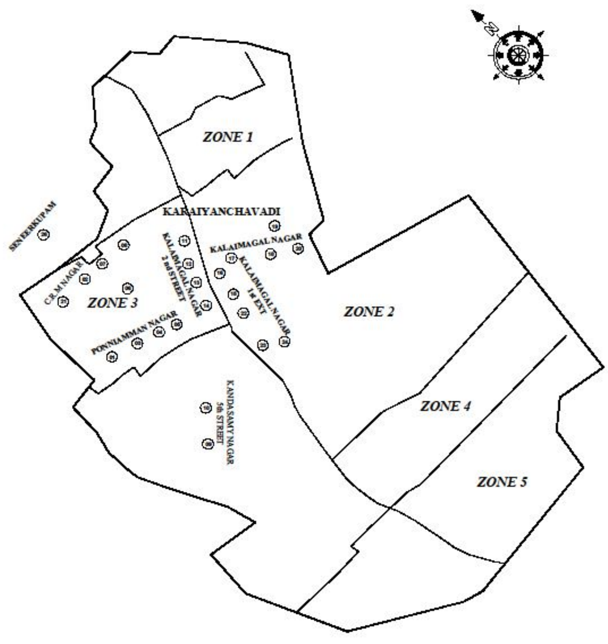

Figure 1: Location Map of Study area.

The temperature is usually in the range of 13.9 to 45° C, and humidity in the range of 65 to 84%. The northeast monsoon during the month of October, November and December chiefly contributes to the rainfall for the district. Most of the precipitation occurs in the form of one or two cyclones caused due to depressions in the Bay of Bengal. The southwest monsoon rainfall is highly erratic and summer rains are negligible. The average annual rainfall in chennai is 1200 mm (1978-2008) (Balakrishnan 2008). Geologically, the district is underlain by formations ranging in age from Archaean to recent. Crystalline rocks comprising charnockites, gneisses and associated rocks are restricted to the western part of the district. The central and eastern parts are underlain by a thick pile of Gondwana shales, clays and sandstones below the recent alluvial deposits.

Assessment of Ground Water Potential

The Groundwater Potential is assessed by using the Water table fluctuation method recommended by the groundwater estimation committee. In this method water table fluctuation in the observation wells is measured periodically. The fluctuations so measured are used along with specific yield to compute groundwater recharge.
The total recharge, discharge and safe yield are calculated using equations suggested by (Raghunath, 1998).

Total Recharge=Area Influence the well x Rise of ground water table
x Specific yield (1)

Total discharge= Area Influence the well x Rise of ground water table
x Specific yield (2)

Total safe yield=Total area x Specific capacity
x Critical draw down (3)

The net safe yield is then calculated by subtracting the overdraft and evaporation loss at the rate of 10% from the safe yield.

To assess the safe yield of the study area the rainfall data for a period of 10years is collected from the meteorological department and the Groundwater level data for a period of 15 years collected from State surface and subsurface water resource data center.

Aquifer Parameter Estimation

Movement and abstraction of groundwater in the geological formations are dependent on the hydrogeological parameters of the aquifers. Evaluation of aquifer parameters, namely, transmissivity T, and storage coefficient S, from aquifer test data has been a continual field research.

Transmissivity (T) is the discharge through the unit depth of the aquifer for a fully saturated depth under unit hydraulic gradient. It is expressed in terms of m^2/sec or lpd/m.

Storage coefficient (S) is defined as the volume of water that an aquifer releases from or takes into storage per unit surface area of the aquifer per unit drop of peizometric surface in case of confined aquifer and per unit drop of water table in case of unconfined aquifer.

Long duration pumping test data and recovery test data of observation wells are considered for determining aquifer parameters for the study area. These data are interpreted using Cooper Jacob's method; Theis curve method and Chow's method (David keith Todd, 2007).

This Curve method

In this method, a plot on logarithmic paper of W(u) versus u known as Type curve is prepared. Then the data curve is prepared using field drawdown data and r^2/t on a logarithmic paper. Now,the data curve is superimposed on the type curve, keeping the coordinate axes of the two curves parallel and adjusted until a position is found by trial whereby most of the plotted points of the observed data fall on a segment of a type curve. Any convenient point is then selected and the coordinates of the match point is recorded. The values of W(u) and u are chosen from the type curve and the values of s and t are chosen from the data curve. Substituting these values in equation (4) and (5), the transmissibility (T) and storage coefficient (S) are determined.

$$T = [(Q / 4\pi s)] \times W(U) \tag{4}$$

$$S = [4uT] \div [r2 / t] \tag{5}$$

Where W (u) refers to Well function, Q refers to Discharge from well, s refers to drawdown, t refers to time since beginning of pumping, r refers to radial distance from pumping well.

Cooper Jacob Method

In this method the observed field draw down data versus time is plotted on a semi log sheet. A straight line is plotted to the data point and its slope is determined. Then the time t_o is noted where the straight line intersects the time axis and the values of transmissibility (T) and storage coefficient (S) are determined using equations given below

$$T = [(2.30\, Q / 4\pi \Delta s)] \tag{6}$$

$$S = [(2.25\, T t_o / r^2)] \tag{7}$$

Where Δs refers to drawdown difference per log cycle, Q refers to Discharge from well, r refers to radial distance from pumping well.

Chows Method

In this method the observed field draw down data versus time is plotted on a semi log sheet. From the graph a tangent was drawn on the curve and the point of tangency was located and the values of s_1, t1, Δs were selected .Then the value of F (u) is calculated .for the calculated value of F(u) ,the values of W(u) and u were obtained from the relation graph. Substituting these values in equation (5) and (6), the transmissibility (T) and storage coefficient (S) is determined.

$$T = [(Q / 4\pi s_1)] \times W(U) \tag{8}$$

$$S = [4uT] \div [r^2 / t_1] \tag{9}$$

Where W (u) refers to Well function, Q refers to Discharge from well, s refers to drawdown, t refers to time since beginning of pumping, r refers to radial distance from pumping well.

From the interpretation, it has been found that the storage coefficient was found to be in the range of 0.012 to 0.049.The transmissivity values varied from 769m^2/day to 1569m^2/day, which is found to be satisfactory for water abstraction from the aquifer.

Results and Discussion

The trend analysis of static water levels observed for a period of 12 years in the network of the observation wells was carried out. Table-1 shows the water level variations in 6 observations wells of the study region. The variation of water level fluctuations with the amount of rainfall in each observation well is shown in Figure 2 – 7.

Table 1: Water Level Variations in OBW (Observation Wells).

Year	Draw down data in Observation Wells (m)					
	OBW-1	OBW-2	OBW-3	OBW-4	OBW-5	OBW-6
2000	1.65	1.85	1.56	1.55	1.46	1.95
2001	-1.96	-2.56	-3.50	-2.56	-3.25	-2.66
2002	-5.60	3.50	2.60	-5.65	2.30	3.45
2003	-1.15	1.50	1.50	-1.25	1.40	1.45
2004	-2.65	2.50	0.05	-2.95	0.03	2.55
2005	1.89	5.50	-1.11	1.59	-1.01	5.25
2006	2.56	-2.10	-1.50	2.76	-1.35	-2.31
2007	3.20	-1.50	-1.05	3.72	-1.15	-1.15
2008	-2.90	-6.20	-0.09	-2.95	-0.04	-6.32
2009	0.05	-3.20	1.15	0.35	1.05	-3.52
2010	0.06	1.50	-1.16	0.26	-1.06	1.50
2011	1.19	2.50	1.01	1.49	0.91	2.50

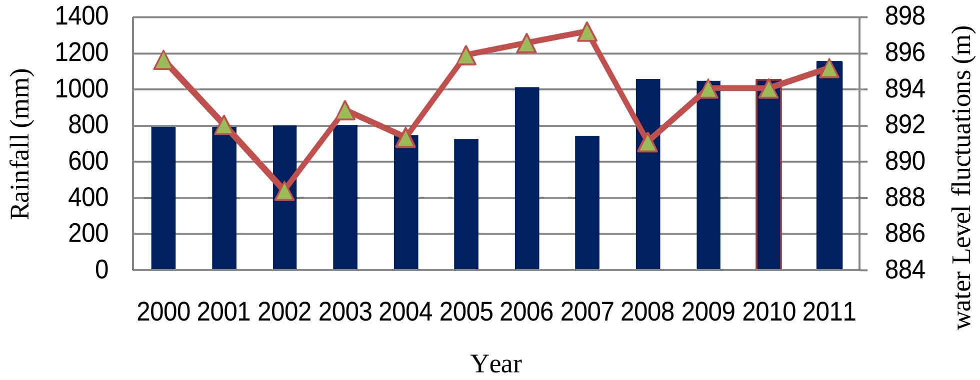

Figure 2: Rainfall with water level fluctuation in Observation Well-1.

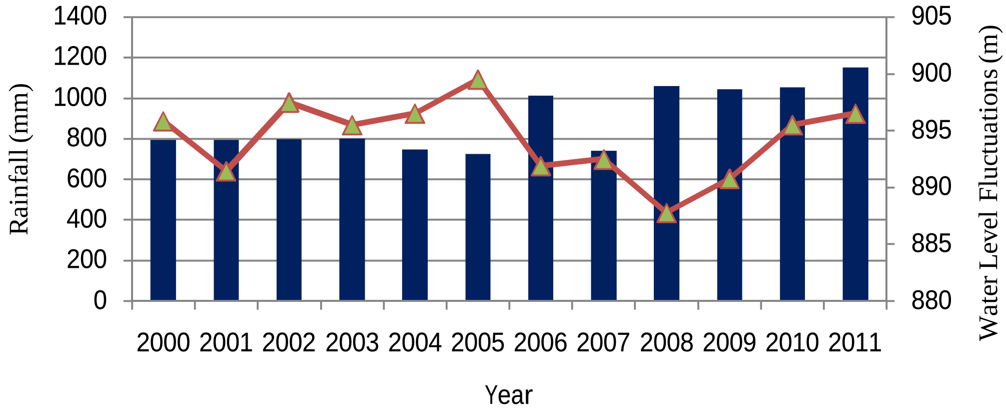

Figure 3: Rainfall with water level fluctuation in Observation Well-2.

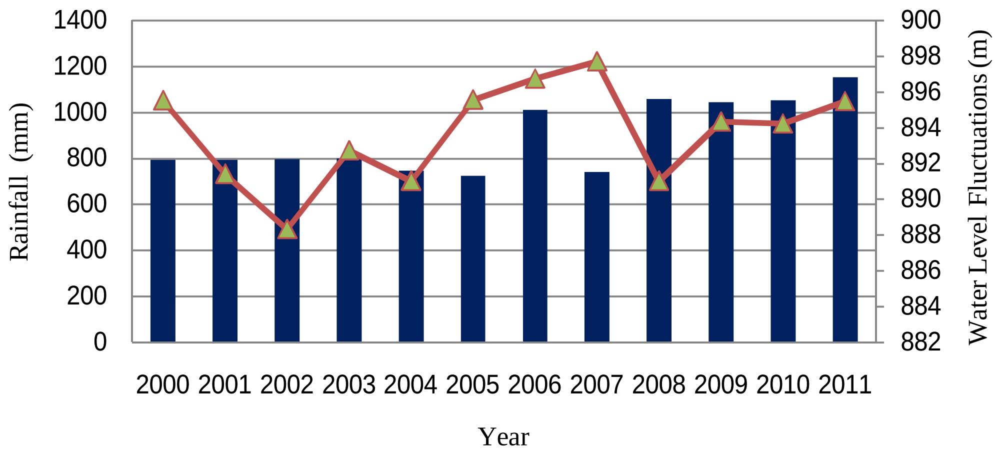

Figure 4: Rainfall with water level fluctuation in Observation Well-4.

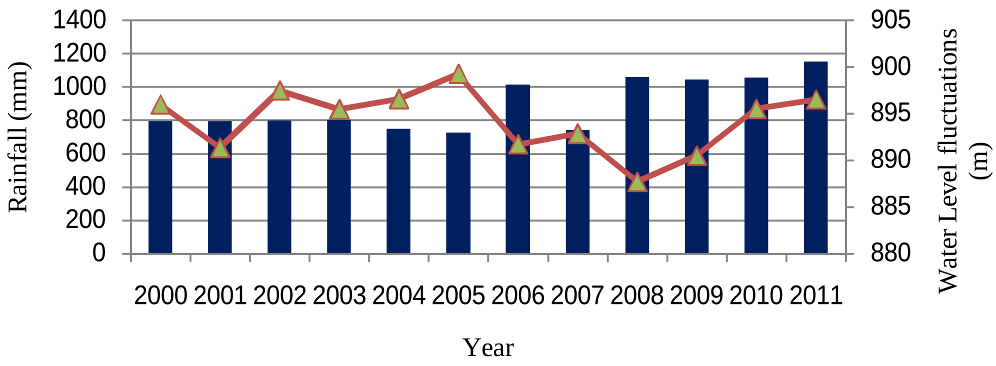

Figure 5: Rainfall with water level fluctuation in Observation Well-6.

Figure-2, 3, 4, 5 shows the variation of water level with amount of rainfall in observation well 1, 2, 4, 6 for 12 years duration. The average value of Rainfall varies from 993mm to 1152mm.It is clearly inferred from the above graph that there was a gradual rise in water level with the increase in rainfall between 2008 and 2011.

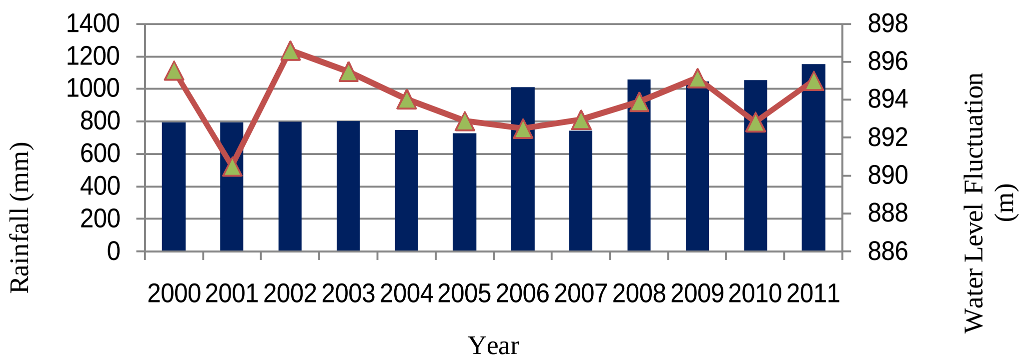

Figure 6: Rainfall with water level fluctuation in Observation Well-3.

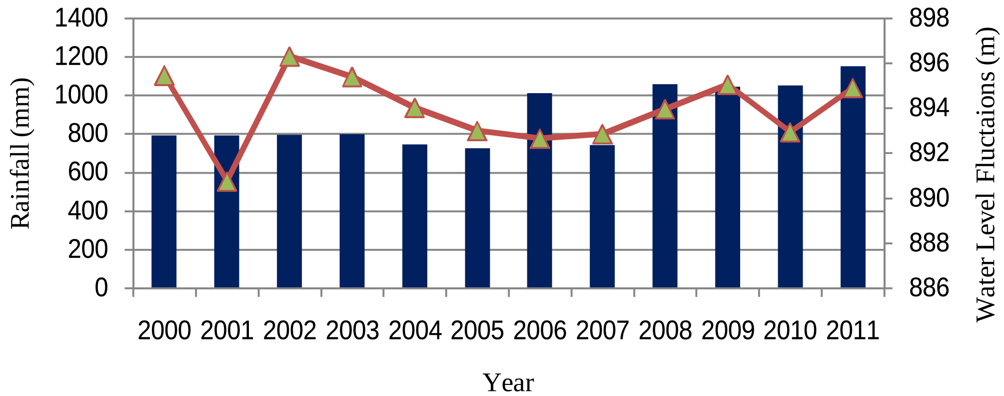

Figure 7: Rainfall with water level fluctuation in Observation Well-5.

Figure- 6, 7 shows the variation of water level with amount of rainfall in observation well 3, 5for 12 years duration. It is clearly inferred from the above graph that there was a gradual decrease in water level with gradual increase in rainfall between 2002 and 2008.This clearly shows that the area influencing observation well 3, 5 has more groundwater exploitation.

The results showed that there was a gradual rise in the water level with the increase in rainfall from the year 2008-2010. However, there was a decrease in water level in most of the observation wells even though an increase in rainfall from the year 2008 to 2010. The net results of the study clearly indicate that there was depletion in the groundwater potential. It was also observed that the quantity of water pumped out in the aquifer was 3.59 Mcum and the recharge estimated was 1.314 M-cum. Hence, it indicates that in the study area as a whole, the groundwater discharge rate was more than the recharge, which leads to groundwater depletion. This is mainly due to unexpected over exploitation, industrialization and urbanization. The estimated safe groundwater potential is 859.59ha-m and the net safe yield after subtracting the overdraft and evaporation loss is 773.63ha-m.

Conclusion

A more adequate description of the groundwater potential should be given in a statistical sense since it implies the statistical properties of the aquifer. The results of the trend analysis of water level variation with the rainfall clearly indicate that there was a gradual rise in water level with increase in rainfall from the year 2008-2010. However, there was a decrease in water levels in most of the observation wells even though there was increase in rainfall from the year 2008 to 2010. This clearly indicates that there was groundwater depletion due to over-exploitation. The estimated safe groundwater potential for the study area is 859.59ha-m and the net safe yield after subtracting the overdraft and evaporation loss is 773.63ha-m.

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