Research Article

Assessment of Natural Ground Water Recharge in South Uppar Odai Watershed of Amaravathi Basin in Tiruppur District

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Abstract

Ground water constitutes a major issue in regions where there is a large demand. Quantification of the rate of natural ground water recharge is a pre-requisite for efficient ground water resource management. It is particularly important in regions with large demands for ground water supplies, where such resources are the keys to economic development. However, the rate of aquifer recharge is one of the most difficult factors to measure in the evaluation of ground water resources. Estimation of recharge, by any method is normally subject to large uncertainties and errors. In this paper, various methods of estimating natural ground water recharge are outlined. The natural recharge of groundwater through rainfall received in the study area was estimated using five empirical approaches. The recharge percentages with these empirical formulae were estimated 18.92, 16.96, 18.81, 8.49 and 12.92 per cent respectively.

Keywords: Ground water, Rainfall, Recharge, Amaravathi basin

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Introduction

The amount of moisture that will eventually reach the water table is defined as natural groundwater recharge, which depends on the rate and duration of rainfall, the subsequent conditions at the upper boundary, the antecedent soil moisture conditions, the water table depth and the soil type. When the sole source of such recharge is precipitation, it called as natural recharge. Ground water constitutes a major issue in regions where there is a large demand, such as in deficit irrigation commands, where irrigation water supply is confined only for few months and farmers have to inevitably depend on ground water, which is a key factor to agricultural development in these areas [1]. Groundwater, a renewable resource is subjected to periodic replenishment primarily through rainfall but is limited primarily to wet season, that is, a few monsoon months in a year. According to an estimate, only 4.1-19.7 per cent of annual rainfall replenished the groundwater in semi-arid regions [2]. Also due to near-total utilization of surface water resources and frequent failure of monsoons, groundwater emerged as major source to meet the ever-increasing demands of irrigation, industry and domestic sectors [3, 4].

Quantification of the rate of ground water recharge is a basic prerequisite for efficient ground water resource management. To meet our water demand, we entirely depend upon rivers, lakes & ground water [5, 6]. However, the rain is the ultimate source that feeds all these sources. The rainfall is highly seasonal and occurs over a short rainy season with a very large dry period. As a result, there is a progressive decrease in the ground water level. Hence, it should be admitted that rain water harvesting is essential because surface water is inadequate to meet our demand and we have to mostly depend on ground water. Ground water recharge is important both for quantifying available water resources and for assessing groundwater vulnerability and also ground water recharge estimates are required for the water resources management.

Materials and methods

Study area

The study area of South Uppar Odai watershed falls under the catchment area of the Amaravathi river basin. Geodetically, the study area is located 10^0 40’ 30”N to 10^0 45’ 30”N latitude and 77^0 15’ 00”E to 77^0 30’ 00”E longitude. The study area falls under the watershed codification of 4B2A7a2. The length of the area is about 18.5km and encompasses the watershed area of about 79.5 km^2. The river Uppar Odai flows into north east direction and the location map of the area is given in **Figure 1**.

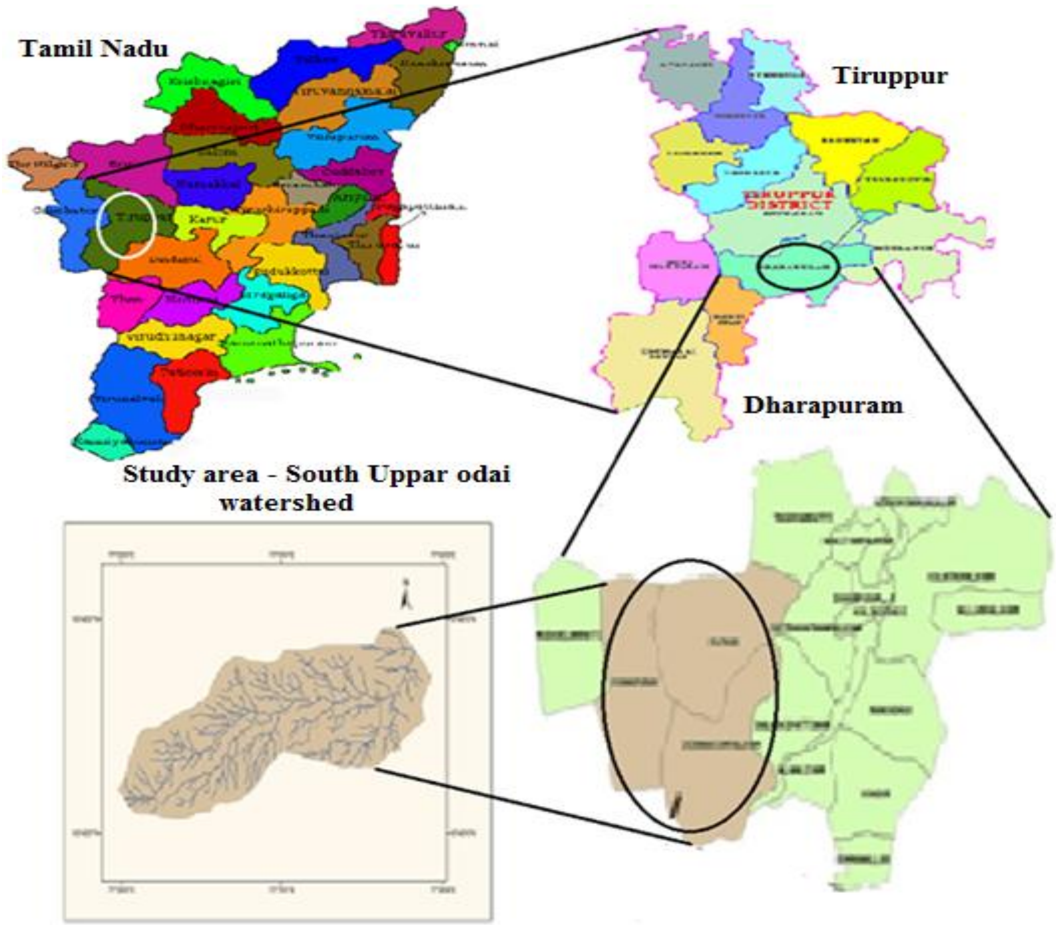

Figure 1 Location map of study area (South Uppar Odai watershed)

Data collection

For assessment of recharge, the daily rainfall data (1982 to 2014) of two rain gauge stations were collected from the State Ground and Surface Water Resource Data Centre of Taramani, Chennai.

Groundwater recharge estimation using empirical formulae

Natural groundwater recharge from rainfall was estimated using following empirical formulae [7].

Chaturvedi formula (1936)

Based on water level fluctuation and rainfall amount in Ganga -Yamua doab Chaturvedi in 1936 derived an empirical relationship to arrive at the recharge as a function of annual precipitation [8].

$$R_g=2\,(P-15)^{0.4}$$

Where, R_g is net recharge, in inches, P is annual rainfall, in inches.

This formula is useful for preliminary estimates of recharge due to rainfall. This formula later modified by U.P. irrigation research institute.

U.P.I.R.I. Formula (1954)

The formula given by Uttar Pradesh Irrigation Research Institute, Roorkee (1954) is as follows [9],

$$R_g = 1.35\,(P-14)^{0.5}$$

Where, R_g is net recharge, in inches, P is annual rainfall, in inches.

Relationship of Krishna Rao

Rao (1970) gave the following empirical relationship in 1970 to determine the groundwater recharge in limited climatological homogenous areas for the different parts. The equation is in the following form [10].

$$R = K (P-X)$$

The following relation is stated to hold good for different parts.

R = 0.20 (P - 400) for areas with P between 400 and 600mm
R = 0.25 (P - 400) for areas with P between 600 and 1000mm
R = 0.35 (P – 600) for areas with P above 2000mm

Where, R = net recharge due to precipitation during the year in mm; P = annual precipitation in mm.

Bhattacharjee formula (1954)

Bhattacharjee (1954) derived an empirical relationship for estimation of rainfall recharge [11]

$$R = 3.47 (P-38)^{0.4}$$

Where, R is groundwater recharge, cm and P is precipitation, cm

Kumar and Seethapathi formula (2002)

Kumar and Seethapathi (2002) proposed following relationship for estimation of recharge from rainfall in upper Ganga canal command area [6],

$$R_g = 0.63 (P-15.28)^{0.76}$$

Where, R_g is groundwater recharge from rainfall in monsoon season, inch and P is mean rainfall in monsoon season, inch.

Statistical parameters used in analysis of groundwater recharge

Calculation of various statistical parameters such as standard deviation, coefficient of variation, coefficient of skewness, coefficient of Kurtosis, Mean have been done for recharge percentage calculated by empirical relationships using rainfall data of 33 years (1982-2014) on yearly basis.

Result and Discussion

The natural recharge of groundwater through rainfall received in the study area were estimated using five empirical approaches i.e. Chaturvedi, UPRI, Bhattacharjee, Krishna rao, Kumar and Seethapathi formulae for 33 years (1982-2014) and presented in **Table 1**. The recharge percentages with these empirical formulae were estimated as 18.92, 16.96, 18.81, 8.49 and 12.92 per cent respectively and recharge of the study area was estimated as 122.82, 110.75, 122.05, 61.06 and 89.05 mm respectively. The recharge percentage with respect to rainfall with all these empirical approaches varies 8 per cent to 19 per cent with an average of 15.22 per cent. From the Table 1, it was concluded that the maximum recharge occurred in the year 2005 as 195.04 mm and minimum recharge occurred in the year 2003 as 43.85 mm.

The standard deviation of recharge estimated using different empirical formulae i.e. Chaturvedi, UPRI, Bhattacharjee, Krishna rao, Kumar and Seethapathi formulae were found 34.22, 33.62, 33.82, 41.66 and 45.73 respectively while standard deviation of average recharge with all empirical formula was found 37.67. The coefficient of skewness was -0.05, 0.15, -0.05, 0.81 and 0.43 respectively for recharge with Chaturvedi, UPRI, Bhattacharjee, Krishna rao, Kumar and Seethapathi formulae and average coefficient of skewness was found -1.04. While coefficient of kurtosis for recharge with Chaturvedi, UPRI, Bhattacharjee, Krishna rao, Kumar and Seethapathi formulae were found -0.72, -0.56, -0.72, 0.78 and -0.09 for average recharge it was -0.28.

Table 1 Estimation of natural recharge in study area using annual rainfall of 33 years (1982-2014)

Year	Rainfall mm	Groundwater Recharge in Per cent						
		Chaturvedi	UPRI	Bhatta charjee	Krishna rao	Kumar and Seethapathi	Recharge (mm)	Recharge (%)
1982	640.73	128.75	114.89	127.88	60.18	91.70	104.68	16.34
1983	547.02	107.64	94.13	107.01	36.75	64.47	82.00	14.99
1984	445.68	73.83	64.58	73.67	11.42	29.80	50.66	11.37
1985	607.08	121.80	107.89	121.00	51.77	82.26	96.94	15.97
1986	455.39	78.08	67.96	77.85	13.85	33.55	54.26	11.91
1987	616.55	123.81	109.91	123.00	54.14	84.95	99.16	16.08
1988	471.65	84.50	73.29	84.17	17.91	39.55	59.89	12.70
1989	650.83	130.73	116.90	129.84	62.71	94.47	106.93	16.43
1990	628.16	126.22	112.33	125.38	57.04	88.21	101.83	16.21
1991	687.15	137.50	123.89	136.54	71.79	104.24	114.79	16.71
1992	799.07	155.75	143.28	154.61	99.77	132.73	137.23	17.17
1993	851.07	163.23	151.45	162.02	112.77	145.31	146.95	17.27
1994	728.50	144.65	131.39	143.62	82.13	115.03	123.36	16.93
1995	429.45	65.77	58.47	65.77	7.36	23.17	44.11	10.27
1996	776.44	152.32	139.57	151.22	94.11	127.14	132.87	17.11
1997	702.10	140.15	126.65	139.16	75.53	108.18	117.93	16.80
1998	806.13	156.80	144.42	155.65	101.53	134.47	138.57	17.19
1999	936.60	174.52	164.00	173.20	134.15	165.30	162.23	17.32
2000	799.25	155.78	143.31	154.64	99.81	132.78	137.26	17.17
2001	577.35	115.12	101.32	114.40	44.34	73.63	89.76	15.55
2002	493.10	92.00	79.78	91.56	23.28	47.05	66.73	13.53
2003	428.85	65.45	58.23	65.44	7.21	22.91	43.85	10.22
2004	565.35	112.25	98.54	111.56	41.34	70.05	86.75	15.34
2005	1134.55	197.14	189.89	195.62	183.64	208.92	195.04	17.19
2006	471.85	84.58	73.36	84.25	17.96	39.62	59.95	12.71
2007	679.60	136.13	122.47	135.19	69.90	102.24	113.19	16.65
2008	856.05	163.92	152.21	162.70	114.01	146.50	147.87	17.27
2009	627.85	126.15	112.26	125.32	56.96	88.13	101.76	16.21
2010	750.70	148.28	135.24	147.21	87.68	120.69	127.82	17.03
2011	661.10	132.70	118.92	131.79	65.28	97.27	109.19	16.52
2012	513.05	98.23	85.37	97.71	28.26	53.70	72.65	14.16
2013	482.60	88.45	76.67	88.06	20.65	43.43	63.45	13.15
2014	439.18	70.77	62.20	70.66	9.79	27.21	48.13	10.96
Mean	644.24	122.82	110.75	122.05	61.06	89.05	101.15	15.22
SD	166.64	34.22	33.62	33.82	41.66	45.73	37.67	2.28
Ck	0.78	-0.72	-0.56	-0.72	0.78	-0.09	-0.33	-0.28
Cs	0.81	-0.05	0.15	-0.05	0.81	0.43	0.28	-1.04

Conclusion

Quantification of the rate of natural ground water recharge is a pre-requisite for efficient ground water resource management. Various mechanism of natural ground water recharge and their importance in the study area are essential when estimating natural ground water recharge. Choice of methods should also be guided by the objectives of the study, available data and the possibilities to get supplementary data. There are possibilities of errors while estimating recharge using empirical formula. Hence, it is desirable to apply more than one method based on independent input data. The natural recharge of groundwater through rainfall received in the study area were estimated using five empirical approaches i.e. Chaturvedi, UPRI, Bhattacharjee, Krishna Rao, Kumar and Seethapathi formulae for 33 years (1982-2014). The recharge percentages with these empirical formulae were estimated as 18.92, 16.96, 18.81, 8.49 and 12.92 per cent, respectively.

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