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ORIGINAL ARTICLE

Ground Water Recharge Potential Using Different Analytical Approaches in Parasai-Sindh Watershed of Babina Block, Bundelkhand Region-A Case Study

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ABSTRACT
This study has been proposed for estimating the ground water recharge potential of shallow dug well by using water table fluctuation (WTF) and rainfall-infiltration factor (RIF) methods in Parasai-Sindh watershed of babina block. The study area was comprises three villages namely Parasai, Chhatpur and Bachhauni covering an area of 1246 ha (12.46 km^2).The data was collected from the selected wells in the study area and annual withdrawal of water for irrigational uses as well as domestic uses have been calculated and found 0.339 million m^3 and 0.091 million m^3 respectively. On the basis of these investigations, net annual ground water availability was observed by WTF and RIF 1.193 million m^{3}and 1.209 million m^{3}respectively.
Keywords: *Rainfall, Runoff, Human Population, Water Level, Well Data*

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INTRODUCTION

Groundwater has now become a major natural resource contributing the water supply system in the country. Groundwater fulfils about 60%irrigation and 80% drinking water requirements of India [1].There are various methods adopting to estimate ground water recharge potential in different areas [3].Water scarcity is a major problem for livelihoods such as drinking, irrigation and textiles etc. For fulfil the requirement of water its rejuvenation must be accomplished which is conceptualised by geological information and recharge mechanics and their importance in the study area. Due to over-reliance and rapid development of irrigation using ground water, Water table is declining at an alarming rate in about15% of India's geographical area [5]. Although there are various well-established methods for the quantitative estimation of recharge, few can be applied successfully in the field. When estimating groundwater recharge it is essential to proceed from a good conceptualization of different recharge mechanisms and their importance in the study area [6]. Besides this conceptualization the objectives of the study, available data and resources, and possibilities of obtaining supplementary data should guide the choice of recharge-estimation methods, [7]. The main objective of this paper is to investigate the possibilities and prospects of availability of ground water and to identify the potentiality of rainwater for recharging shallow dug well in Bundelkhand region.

MATERIAL AND METHODS

Description of Study Site

The study was conducted at Parasai-Sindh watershed area of 1246 hectares. Study area Constituted three villages namely Parasai, Chhatpur and Bachhauni which is located in Babina block of Jhansi District, Bundelkhand region. The watershed located between 25^o 23' 47.6" - 25^o 27' 05.1" latitude and 78^o 20' 06.5" -78^o 22'33.0" longitude (Fig. 1).The agro-climate of the study area is characterized by dry and hot summer, warm and moist rainy season and cool winter with occasional rain showers. The mean summer (April-May-June) temperature is 34 ^{0}C which may rise to maximum of 46 to 49 ^{0}C during May and June.

The mean winter temperature (December-January-February) is 16 ^{0}C which may drop to 3-5 ^{0}C in December and January.

The annual rainfall of the Bundelkhand region varies from 800 to 1300 mm, about 90% of which is received during South-West monsoon period [8]. Long term weather data monitored at Jhansi station shows that annual average rainfall in region is 877 mm with about 85 % falling from June to September. The numbers of rainy days during the monsoon and non-monsoon period are 42 and 13, on average, respectively. The total rainy days/year vary from 30-45 in the region with an average of 37.

The geology of the study area is dominated by hard rocks of archaen granite and gneiss and largely composed of crystalline igneous and metamorphic rocks and aquifers are either unconfined or perched, having poor storage capacity (porosity of 0.01-0.05 %). In such hard rock aquifers with poor transmissibility, shallow dug wells of 5 to 15 m depth are only primary source of water for domestic and agricultural use in this region. Due to undulated topography, poor groundwater potential, high temperature, poor and erratic rainfall, agricultural productivity in this region is very poor (0.5-1.5 t ha^{-1}).The length of growing season in Bundelkhand ranges between 90 to 150 days depending upon rainfall and temperature regimes. The soils of the study area can be conveniently grouped into major soil groups viz., red soils and black soils.

The red soils are coarse grained upland soils while black soils are heavy soils. These soils are further classified according to their texture and colour into four distinct series namely Rakar and Parwa in red soils and Kabar and Mar in black soils. The type 1A Rakar soils are the soils of rocky ridges and are not important agriculturally. The other type I B is shallow (10-50 cm), reddish to brownish red in colour having immature profile development (Alfisols and Entisols) which is characterized by coarse gravelly and light textured with poor water holding capacity.

Based on the land use, drainage network, slope, geomorphology and lithology of the area thirty dug wells were identified and proposed for assessment the availability of ground water in whole watershed of Babina block. The water level of selected wells was monitored on daily basis during pre and post monsoon for groundwater recharge estimation. Ground water recharge in selected wells of watershed is estimated by ground water table fluctuation method during pre and post monsoon and specific yield method by well accepted technique. Natural discharges and other losses was considered 45 % of annual ground water recharge [1]. Annual ground water recharge = area*average water table fluctuation *specific yield

Specific Yield = P*Rg/HW*(P-Rs)

Where P is the annual rainfall, Rg is the annual groundwater runoff, Rs is the annual surface runoff and Hw is the water table fluctuation.

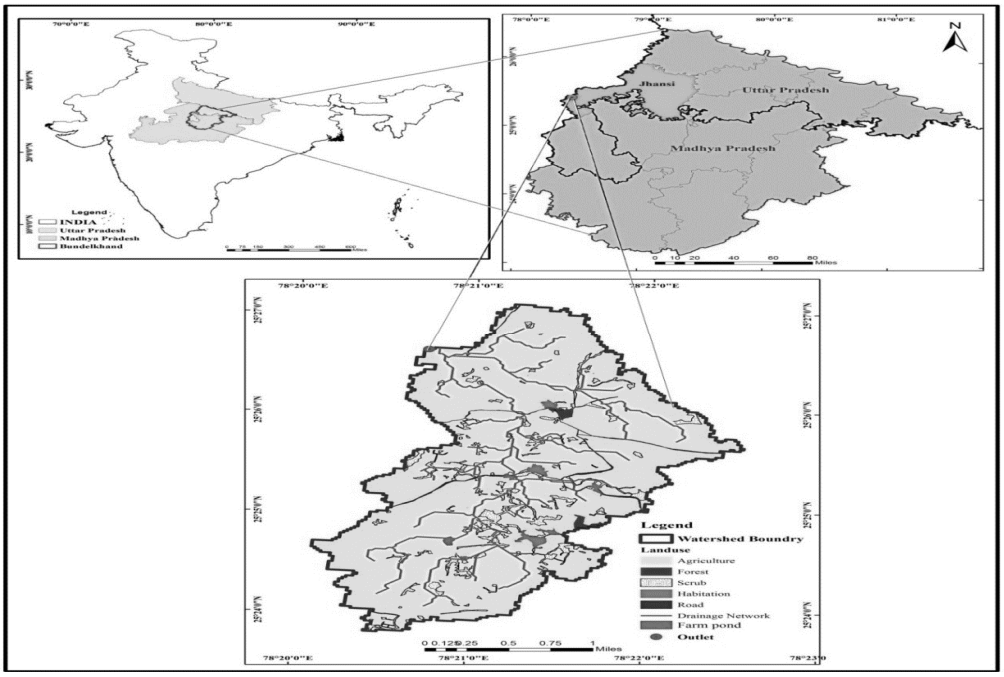

Fig.1. Location map of Parasai-Sindh watershed

As reported in the GEC Report- 1997, for semi-consolidated sandstones and weathered and fractured hard rock terrains, a rainfall infiltration factor of 10–15% of normal rainfall and for sandy areas

infiltration factor of 20–25% may be undertaken for calculation of ground water recharge potential. Here, we have considered an average 15% rainfall infiltration factor for calculating annual ground water recharge of the area.

Annual ground water recharge = area * average rainfall * infiltration factor

Ground Water Assessment Report-1997 prepare by CGWB, the consumption rate of 70 litre per day per person was considered. Return flow from irrigation to ground water and other losses considered 20% of total irrigation draft and consumption by cattle population was projected as 10% of domestic consumption.

RESULTS AND DISCUSSION

Digital Elevation Model (DEM) and slope gives an idea about the topography and level of inclination of the study area. Land use of Parasai-Sindh watershed was categorized in six types. Maximum area is under agricultural land (88.7%) followed by scrub land (5.29%), drainage network (3.6%), road (1.15%), habitat (0.89%) and very small area covered by forest (0.45%).

The results of this study indicate that in pre-monsoon, minimum water level of wells was 5.14 m, whereas, 13.86 m was recorded maximum water level. Minimum and maximum water level of wells was recorded 2.13 m and 9.52 m, in post-monsoon season. Water availability at the end of monsoon was dependent on groundwater recharge in current year. The hydraulic head (difference in water level) of wells was recorded 8.72 m and 7.39 m while average water level of wells was recorded 8.607 m and 5.382 m respectively in pre and post-monsoon. The minimum and maximum fluctuation of water level in wells was observed 0.57 m and 6.12 m respectively while average fluctuation was observed 3.224 m (Table 1).

Table 1. Water level fluctuation at different location of Babina block in Bundelkhand Region

Well No.	Location	Pre-monsoon (m)	Post-monsoon (m)	Fluctuation (m)
1	25° 25′ 28.1″ N 78° 21′ 29.5″ E	7.18	2.53	4.65
2	25° 25′ 29.7″ N 78° 21′ 43.0″ E	7.98	6.15	1.83
3	25° 25′ 27.2″ N 78° 21′ 42.4″ E	10.15	7.1	3.05
4	25° 25′ 21.3″ N 78° 21′ 40.9″ E	8.55	3.45	5.1
5	25° 25′ 19.3″ N 78° 21′ 47.7″ E	8.06	4	4.06
6	25° 25′ 17.3″ N 78° 21′ 48.5″ E	7.55	2.93	4.62
7	25° 25′ 15.4″ N 78° 21′ 49.0″ E	6.95	3.65	3.3
8	25° 25′ 12.7″ N 78° 21′ 49.5″ E	8.25	2.13	6.12
9	25° 25′ 17.3″ N 78° 21′ 51.8″ E	8.84	2.83	6.01
10	25° 25′ 22.2″ N 78° 21′ 48.2″ E	9.25	5.1	4.15
11	25° 24′ 37.6″ N 78° 21′ 22.3″ E	8.15	4.93	3.22
12	25° 24′ 39.2″ N 78° 21′ 23.5″ E	7.82	6.69	1.13
13	25° 24′ 42.4″ N 78° 21′ 26.2″ E	11.85	8.36	3.49
14	25° 24′ 45.2″ N 78° 21′ 31.6″ E	10.75	8.3	2.45
15	25° 24′ 43.9″ N 78° 21′ 33.8″ E	11.94	9.52	2.42
16	25° 24′ 41.1″ N 78° 21′ 35.3″ E	13.86	8.96	4.9
17	25° 24′ 39.2″ N 78° 21′ 40.5″ E	13.38	8.6	4.78
18	25° 24′ 42.8″ N 78° 21′ 44.1″ E	10.86	8.68	2.18
19	26° 24′ 57.6″ N 78° 21′ 44.8″ E	7.81	4.36	3.45
20	26° 24′ 53.5″ N 78° 21′ 42.0″ E	10.44	7.15	3.29
21	26° 26′ 26.6″ N 78° 21′ 18.3″ E	6.29	3.72	2.57
22	26° 26′ 27.5″ N 78° 21′ 16.7″ E	5.96	4.3	1.66
23	26° 26′ 29.1″ N 78° 21′ 11.6″ E	5.66	3.47	2.19
24	26° 26′ 30.0″ N 78° 21′ 18.3″ E	5.14	4.57	0.57
25	25° 26′ 22.0″ N 78° 21′ 33.4″ E	8.35	4.7	3.65
26	25° 26′ 23.0″ N 78° 21′ 30.6″ E	7.59	5.6	1.99
27	25° 26′ 27.5″ N 78° 21′ 35.1″ E	9.22	7.1	2.12
28	25° 26′ 28.0″ N 78° 21′ 31.6″ E	7.32	4.2	3.12
29	25° 26′ 28.7″ N 78° 21′ 25.3″ E	5.88	3.9	1.98
30	25° 26′ 29.1″ N 78° 21′ 23.0″ E	7.18	4.5	2.68
Minimum water level		5.14	2.13	0.57
Maximum water level		13.86	9.52	6.12
Hydraulic head		8.72	7.39	1.33
Average water level		8.607	5.382	3.224

Singh *et al.* [9] recorded on an average 4.0 m difference in hydraulic head in open wells before and after monsoon period for Garhkundar watershed of Bundelkhand region. Garg and Wani [2] also reported 4.5 m difference in hydraulic head (difference in water label) in open wells before and after monsoon period in Kothapalli watershed of semi-arid tropics. The change in ground water storage volume during pre and post-monsoon period was estimated by ground water level fluctuation method. The variations of water level in wells during pre and post-monsoon period was due to several factors including local hydrogeology, topography, daily rainfall data during monsoon season and also types of facilities available for artificial recharge of groundwater through rainwater harvesting etc.

The rainfall varies from 800 to 1300 mm while average rainfall is 877 mm. Ground water runoff and surface runoff was recorded 105.24 mm and 225.36 mm respectively. Human population was recorded 3200 in the study area. Bundelkhand region under comes in semi-arid tropics so infiltration factor was considered 0.15 for calculating annual ground water recharge of the area by rainfall-infiltration factor method. Different parameters for estimation of ground water availability by different analytical methods was recorded (Table 2).The maximum water level behaviour in pre-monsoon was found 13.6 m in well 16 and minimum 5.14 in well-22. In post-monsoon maximum water level was recorded 9.52 in well-15 and minimum 2.13 m in well-08. The maximum fluctuation in water level was found 6.12m inwell-08 and minimum 0.57 m in well-24 (Fig.2).

Table 2. Different parameters for estimation of ground water availability in Babina block

S. No.	Parameters		Pre-monsoon	Post-monsoon	Fluctuation
1	Area	12.46 km^2	-	-	-
2	Average Rainfall	877 mm	-	-	-
3	Average water level	-	8.607 m	5.382 m	3.224 m
4	Ground water runoff	105.24 mm		-	-
5	Surface runoff	225.36 mm		-	-
6	Infiltration factor	0.15	-		-
7	Human population	3200	-		-

Table 3. Estimating net annual ground water availability in Babina block

Methods	Specific yield (m)	Annual ground water recharge (million m^3)	Irrigation Uses (million m^3)	Domestic uses (million m^3)	Net annual ground water availability (million m^3)
Water table fluctuation	0.039	1.623	0.339	0.091	1.193
Rainfall-infiltration factor		1.639	0.339	0.091	1.209

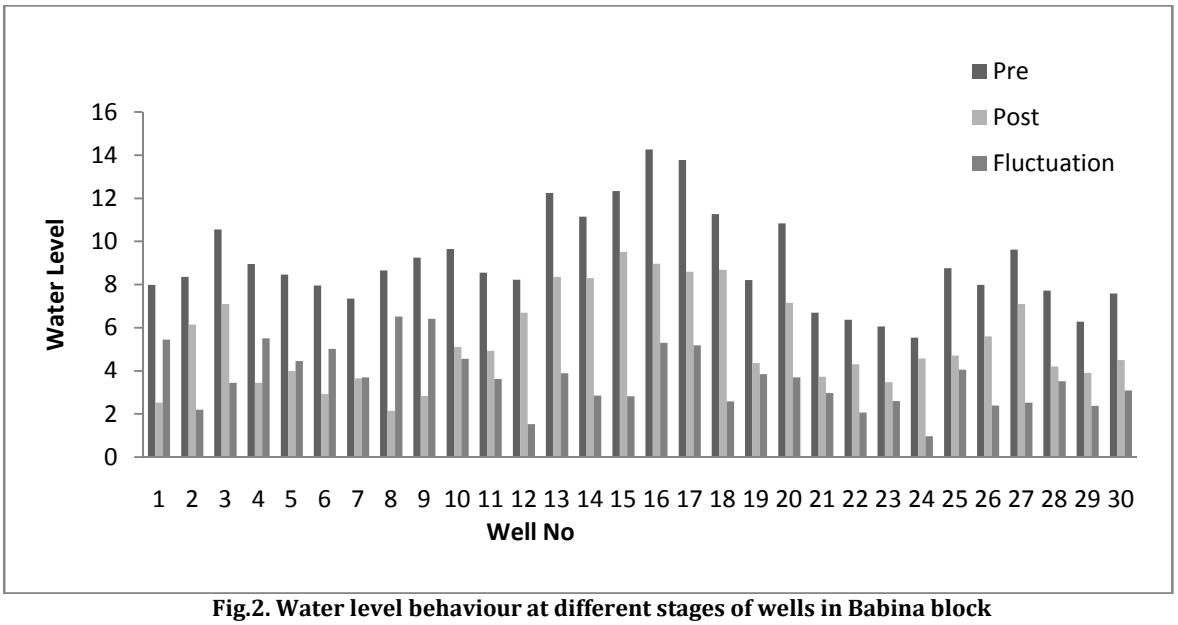

Fig.2. Water level behaviour at different stages of wells in Babina block

CONCLUSION

The results shows that total annual ground water recharge in million m^3 per year has been calculated as 1.623 million m^3 and 1.639 million m^3 by water table fluctuation (WTF) and rainfall-infiltration factor (RIF) methods whereas for the annual ground water withdrawal 2 major sub units such as (i) Annual water withdrawal for irrigation uses (ii) Domestic withdrawal have been taken into account and on the basis of these results, Net Annual Ground Water Availability has been estimated as 1.193 million m^3 and 1.209 million m^3 which seems to be quite high and is sufficient to meet the requirement of the people.

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