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Study of Water Table Behavior by Using Recharge Unit in Babina Block, Bundelkhand Region, Central India

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ABSTRACT: The study was undertaken in Babina block of Bundelkhand region, Central India to investigate the water table behavior in treated (Recharge unit) and control dug well during monsoon season because Bundelkhand region is a hub of drought due to erratic rainfall, undulated topography and hard rock terrains. Due to lack of interventions and rugged topography, most of the part of rainfall converts into runoff and meet to the river. In this way, a recharge unit with recharge filter was constructed for collecting the water into the wells which supports to increase the water level in the wells. Artificial recharge is one technique used to manage water resources and is being promoted as a significant solution to water scarcity in arid and semi-arid regions. Artificial recharge to the aquifer is the process of draining the rain water or surface water into the aquifer by dug wells and recharge (soak) pits to revitalize the wells. Artificial recharge is the process by which the ground water is augmented at a rate much higher than those under natural condition of replenishment. This unit was implemented 3 m away from the well. Behavior of water table is maximum in control shallow dug well during September in spite of less rainfall 42.6 mm as comparison to treated shallow dug well due to impounding the maximum part of rainfall as well as runoff. At 476.2 mm rainfall, water level is started to maintain the level of ground water recharge but less water is rise due to more infiltration and less runoff which increase the level of water in control shallow dug well. At 591.2 mm rainfall when soil is saturated then runoff is more than infiltration to helpful the rising of water level in treated shallow dug well and reach the equilibrium position. The results reveals that control shallow dug well may be helpful to supply water in whole year as comparison to treated shallow dug well.

Keywords: Rainfall, shallow dug well, well recharge unit, water table and measuring device.

INTRODUCTION

Availability of ground water in wells as well as other water courses has become a major natural resource contributing the water supply for livelihood security like India but most of the portion of rainfall convert into runoff and rarely met to river system. Groundwater fulfils about 60% irrigation and 80% drinking water requirements of India (CWC, 2007). Semi-arid Bundelkhand, the home of over 15.62 million humans and8.36 million livestock, suffers from water scarcity, natural resource degradation, low crop productivity (1–1.5 Mg/ha), low rainwater use efficiency (35–45%), high erosion, poor soil fertility, requent droughts, poor irrigation facilities, heavy biotic pressure on forests, inadequate vegetation cover and frequent crop failure resulting in scarcity of food, fodder and fuel (Palsaniya *et al.*, 2008). In alluvial as well as hard rock areas, there are thousands of dug wells, which have either gone dry, or the water levels have declined considerably. These dug wells can be used as structures to recharge the ground water (Thornthwaite, 1948). Due to inadequate access to safe water about 2,00,000 people dying every year, the situation is likely to worsen as the demand for water will exceed the supply by 2050 (CWMI, 2018). 24 Indian cities will run out of groundwater by 2020, affecting 100 million people; 40% of India's population will have no access to drinking water by 2030 (NITI Ayog, 2018). Water Index scores vary widely across states, but most states have achieved a score below 50% and could significantly improve their water resource management practices, Uttar Pradesh scoring 38% under comes in below performance (Composite Water Management Index reported, 2018). Soil conservation practices like small size field with bund, vegetation, mulching practices etc. are implemented for reducing the water velocity and increase the infiltration rate to recharge the wells. Though groundwater has played a vital role in stabilizing Indian agriculture but indiscriminate use has resulted in fast depletion and degradation of this key natural resource. Water table is declining at an alarming rate in about 15% of India's geographical area (Kamra and Sharma, 2011). Artificial recharge to the aquifer is the process of draining the rain water or surface water into the aquifer by dug wells and recharge (soak) pits to revitalize the wells. Artificial recharge is the process by which the ground water is augmented at a rate much higher than those under natural condition of replenishment. The basic requirement for recharging ground water is source of water availability. The availability of source water is basically assessed in terms of surplus monsoon run off. Shallow dug wells are recharge artificially by construction of recharge unit into an aquifer. Physical impurities of runoff water must be obstructed by filtering unit which prevents entry into the recharge system. The filtration unit must perform effectively to get potential benefits from the installed recharge structures it depends on hydraulic efficiency and the filtration effectiveness (Martinson and Thomas, 2005). The main purpose of this study is to investigate the possibilities and prospects to recharge shallow dug well and to indentify the potentiality in Bundelkhand region.

MATERIAL AND METHODS

The study was carried out in Babina block, located at 25 o 23' 47 .6" - 25 o 27' 05.1" latitude and 78° 20' 06.5" -78°22'33.0" longitude Bundelkhad region, Central India. The status of annual rainfall in the watershed is variable with arrange of 800 to 1300 mm with average rainfall of 877 mm. The length of growing season in Bundelkhand ranges between 90 and 150 days, depending upon rainfall and temperature regimes. Wheat is the major crop during rabi season and groundnut is the major crop in the kharif season. Long term weather data show that the average rainfall in study region is 877 mm, about 85% falling from June to September (Singh *et al.,* 2014). Mean annual temperature ranges from 24 to 25 °C. The mean summer (April-May-June) temperature is 34 °C which may rise to a maximum of 46 to 49 °C during the month of May and June. The mean winter temperature (December-January-February) is 16 °C.

There are very rugged landscape, featuring undulated terrain with low rocky outcrops, narrow valleys and plains. Watershed has a semiarid tropical climate and is characterized by dry and hot summer, warm and moist rainy season and cool winter with occasional rain showers. The study is depending upon hydrogeology, topography, daily rainfall, vegetation, artificial recharge system through rainwater harvesting, base flow and climatic data. Two automatic rain gauges were installed for recording daily rainfall data in the study area. Twenty five shallow dug wells were selected for the ground water recharging in the whole watershed area. These wells were either gone dry or the water levels have declined considerably during summer months. Out of these wells two wells were selected for study in which in one well for control and another for treated (recharge unit). The depth and diameter of both selected wells was equal i.e., 10.5 and 6 m, respectively. The recharging unit was designed for artificial recharge along with having sediment trap pit and recharge filter unit. The specification of recharge filter unit having 6 layer of fine sand, coarse sand , small concrete grit, pebble and stone of 0.2 mm, 2 mm, 2 cm, 5 cm, 10 cm and 20 cm diameter respectively (Fig. 2). The distance of recharge filter from well was considered as 3 m from which water allowed to pass into the well. The data was recorded by manually in daily at treated and control well for comparative study of ground water recharge as well as water table behavior and identify the most suitable to avail the water in selected area.

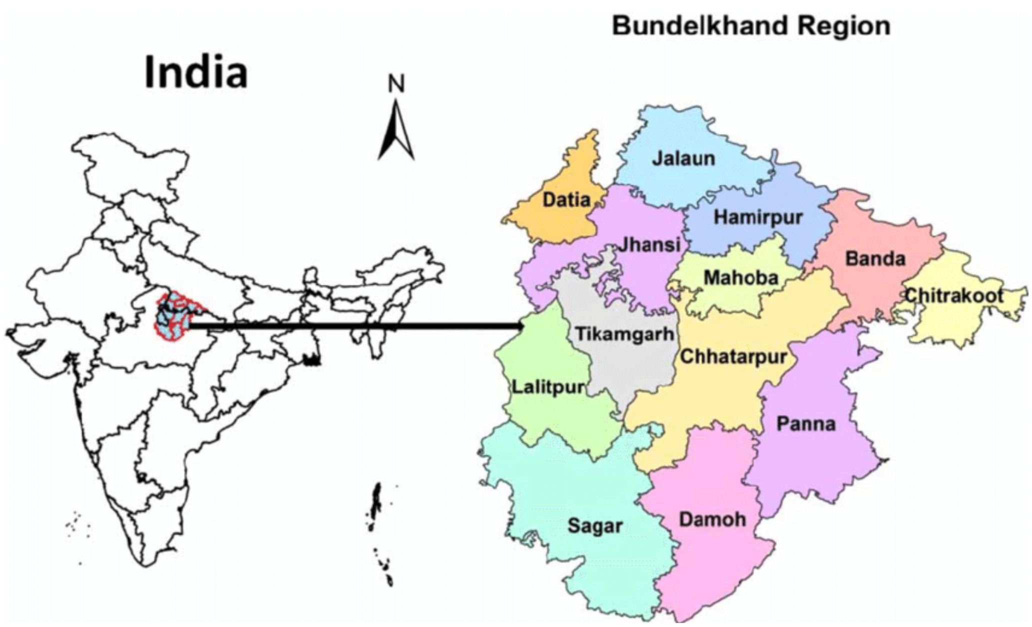

Fig. 1. Location map of study area.

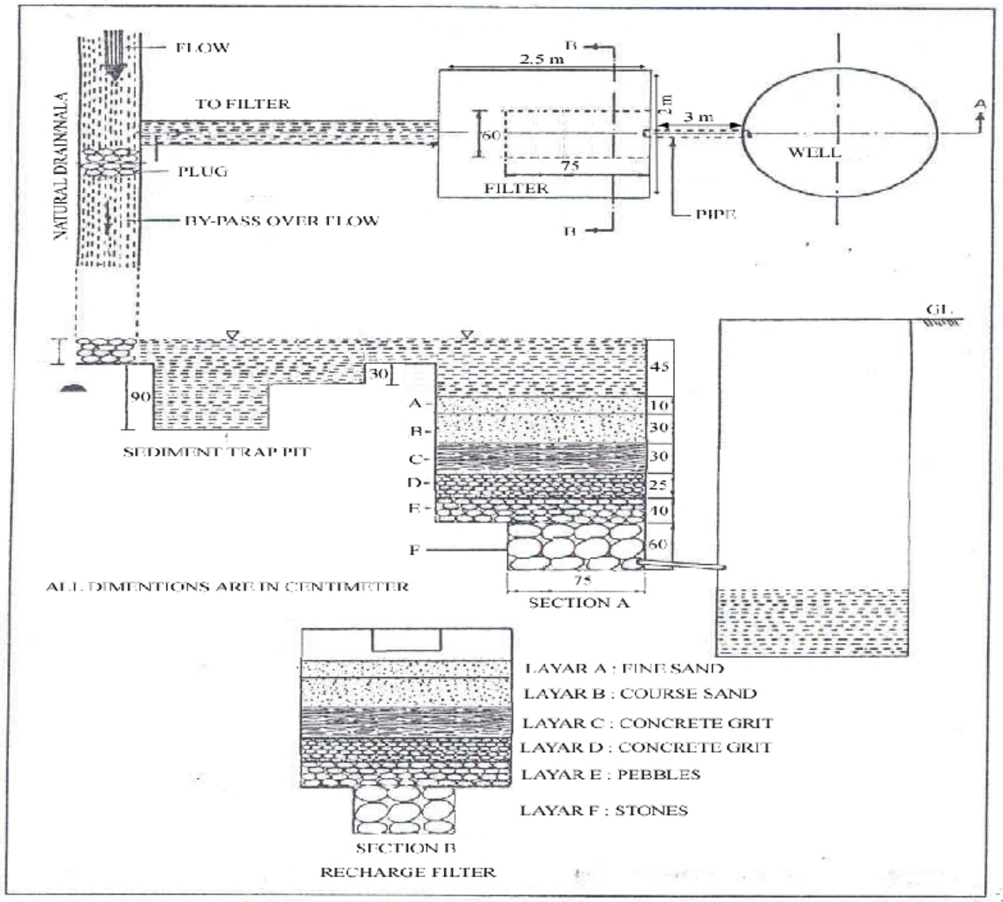

Fig. 2. Well recharging unit with recharge filter.

RESULTS AND DISCUSSION

A digital Elevation Model (DEM) and slope map gives an idea about the topography and level of inclination of the study area which supports during the construction of recharge unit. Maximum area is under agricultural land (109.7%) followed by scrub land (16.26%), drainage network (5.3%), road (3.25%), habitat (1.89) and very small area covered by forest (3.17%). The water table behavior for the month of June was observed maximum as comparison to control well from beginning of monsoon in month of June along with rainfall (Fig. 3).

Water level in treated well varies from 3.6 m to 3.95 m while 3.5 m to 3.95 m was recorded as in control well. The variation in water level in shallow wells due to base flow and direct flow of runoff into the wells through recharge structure is shown in Table 1. An average 4.0 m difference in hydraulic head in open wells before and after monsoon period for Garhkundar watershed of Bundelkhand region (Singh *et al.*, 2014).

According to study of DEM and slope map of study area, different types of recharge structures were proposed but artificial recharge structure was found most suitable and sustainable in hard rock areas where the dug wells have gone either dry or the water level have declined. The wells which was exited recharge by dug well method. Artificial recharge method was found well suited where wells was located at upper ridge of study area. In study area, out of approximately 325 wells, almost 25% wells were found dry soon after monsoon hence these wells received first priority with less expenditure. The artificial recharge of ground water was done by using well recharging unit (WRU) in the watershed. The data was collected on daily basis during monsoon season (June to October).

Similarly the study in month of July revealed that water level increased in control well as comparison to treated well and constant approximately in treated well (Fig. 4). Water level is increased in control well from 4.15 m to 6.45 m while in treated well the water level is constant at 3.95 m (Table 2). In month of August, both wells as treated and control having constant water level but initially increased in treated well and at the end of month control well increased the water level (Fig. 5). The level of water increased at 7.8 m and 7.9 m approximately which is almost near about to each other and maintain the ground water recharge (Table 3).

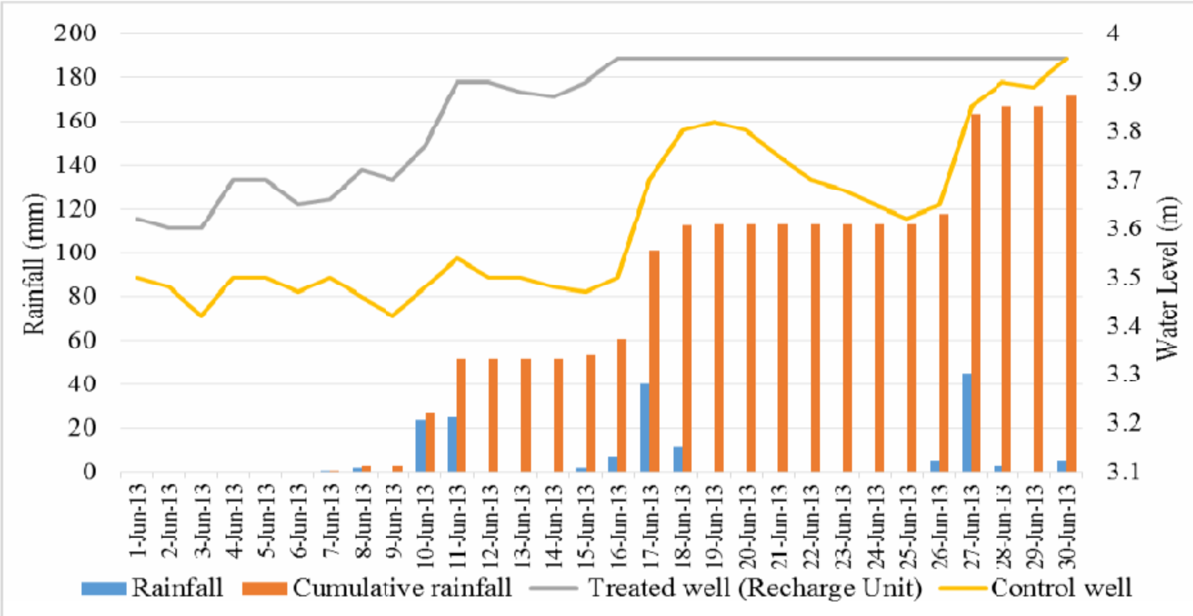

Fig. 3. Water table behavior for the month of June.

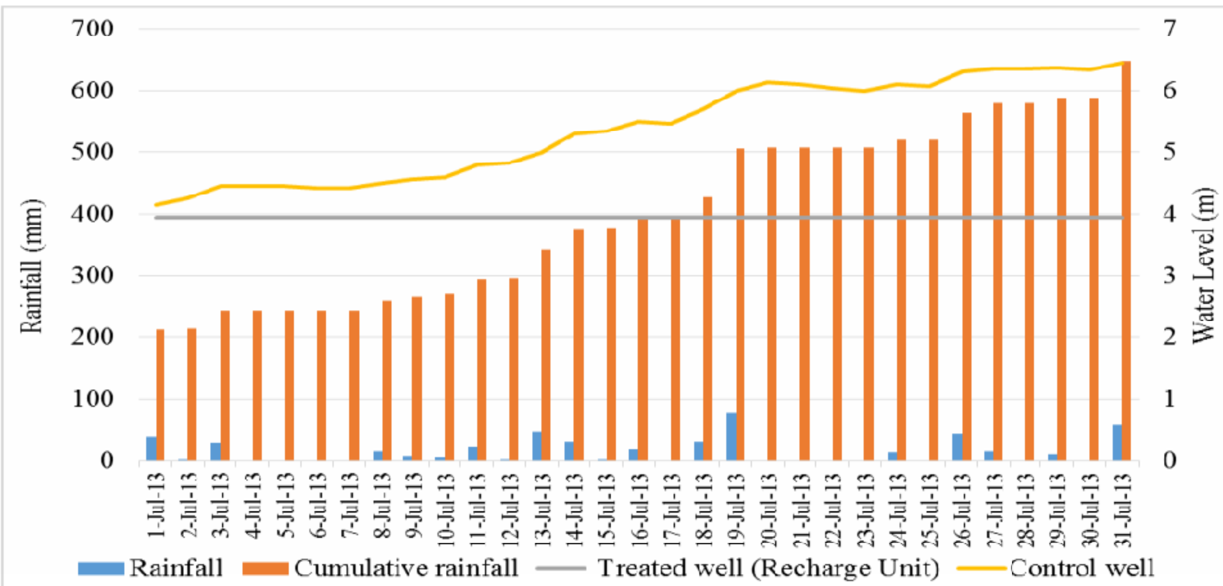

Fig. 4. Water table behavior for the month of July.

Similarly study of remaining months, it was observed that the maximum water level was recorded in control wells due to base flow generation by 2-3 times and maintain the water table (Fig. 6 &7).

The water table behavior in month of September is approximately constant for both treated and control wells but after monsoon in the month of October the water table started to decline at treated wells while in control wells it is found to be constant (Table 4 & 5). The results of this study reveals that in pre-monsoon, water level was recorded as 3.95 and 3.89 m in treated well and control well respectively while after post-monsoon, water level was recorded as 7.89 m in treated well and 7.12 m in control well. Water availability at the end of monsoon was dependent on groundwater recharge in current year. Singh *et al.,* (2014) 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 (2013) 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. Reena *et al.* (2014) recorded the increase groundwater storage in the wells as 11.47% by WRU in the Bundelkhand region.

Table 1: Water level status along with rainfall for the month of June.

Rainfall (mm)	Water level in Treated well (m)	Water level in Control well (m)
0	3.62	3.5
0	3.6	3.48
0	3.6	3.42
0	3.7	3.5
0	3.7	3.5
0	3.65	3.47
0.8	3.66	3.5
2.2	3.72	3.46
0	3.7	3.42
23.6	3.77	3.48
25	3.9	3.54
0	3.9	3.5
0	3.88	3.5
0	3.87	3.48
2	3.9	3.47
7.2	3.95	3.5
40.4	3.95	3.7
11.4	3.95	3.8
0.2	3.95	3.82
0	3.95	3.8
0	3.95	3.75
0	3.95	3.7
0	3.95	3.68
0	3.95	3.65
0	3.95	3.62
5.2	3.95	3.65
45.4	3.95	3.85
3	3.95	3.9
0	3.95	3.89
5.2	3.95	3.95

Table 2: Water level status along with rainfall for the month of July.

Rainfall (mm)	Water level in Treated well (m)	Water level in Control well (m)
39.4	3.95	4.15
3	3.95	4.26
30	3.95	4.45
0	3.95	4.45
0	3.95	4.45
0	3.95	4.43
0	3.95	4.42
15	3.95	4.5
6.6	3.95	4.56
4.8	3.95	4.6
24.2	3.95	4.8
2	3.95	4.82
46.4	3.95	5
31.2	3.95	5.3
2.8	3.95	5.35
17.6	3.95	5.5
0	3.95	5.48
32.2	3.95	5.7
79.2	3.95	6
1.4	3.95	6.13
0	3.95	6.1
0	3.95	6.04
0	3.95	6
13.8	3.95	6.11
0	3.95	6.08
43.6	3.95	6.3
14.4	3.95	6.35
0.6	3.95	6.35
9.6	3.95	6.37
0	3.95	6.33
58.4	3.95	6.45

Table 3: Water level status along with rainfall for the month of August.

Rainfall (mm)	Water level in Treated well (m)	Water level in Control well (m)
49.2	3.95	6.7
4.4	3.95	6.7
18.8	3.95	6.8
0	7.68	6.8
18.4	7.8	6.95
37.6	7.8	7.22
1	7.8	7.22
24.6	7.8	7.45
53.2	7.8	7.45
2	7.8	7.45
0.8	7.8	7.45
7.8	7.8	7.45
6.4	7.8	7.45
0	7.8	7.45
0	7.8	7.45
0	7.8	7.45
72.4	7.8	7.45
52.6	7.8	7.45
80.4	7.8	7.85
3.2	7.8	7.85
33.4	7.8	7.9
22.2	7.8	7.9
11.8	7.8	7.9
0	7.8	7.9
0	7.8	7.9
0	7.8	7.9
0	7.8	7.9
0	7.8	7.9
2	7.8	7.9
86.8	7.8	7.9
2.2	7.8	7.9

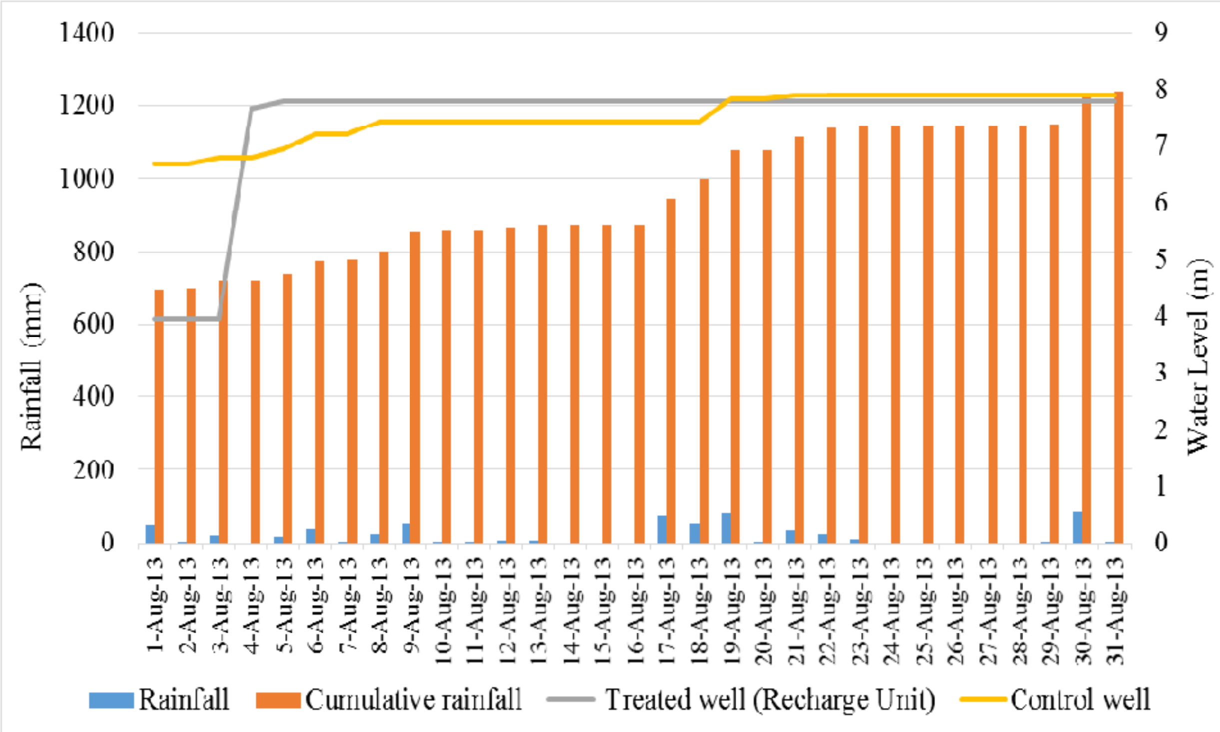

Fig. 5. Water table behavior for the month of August.

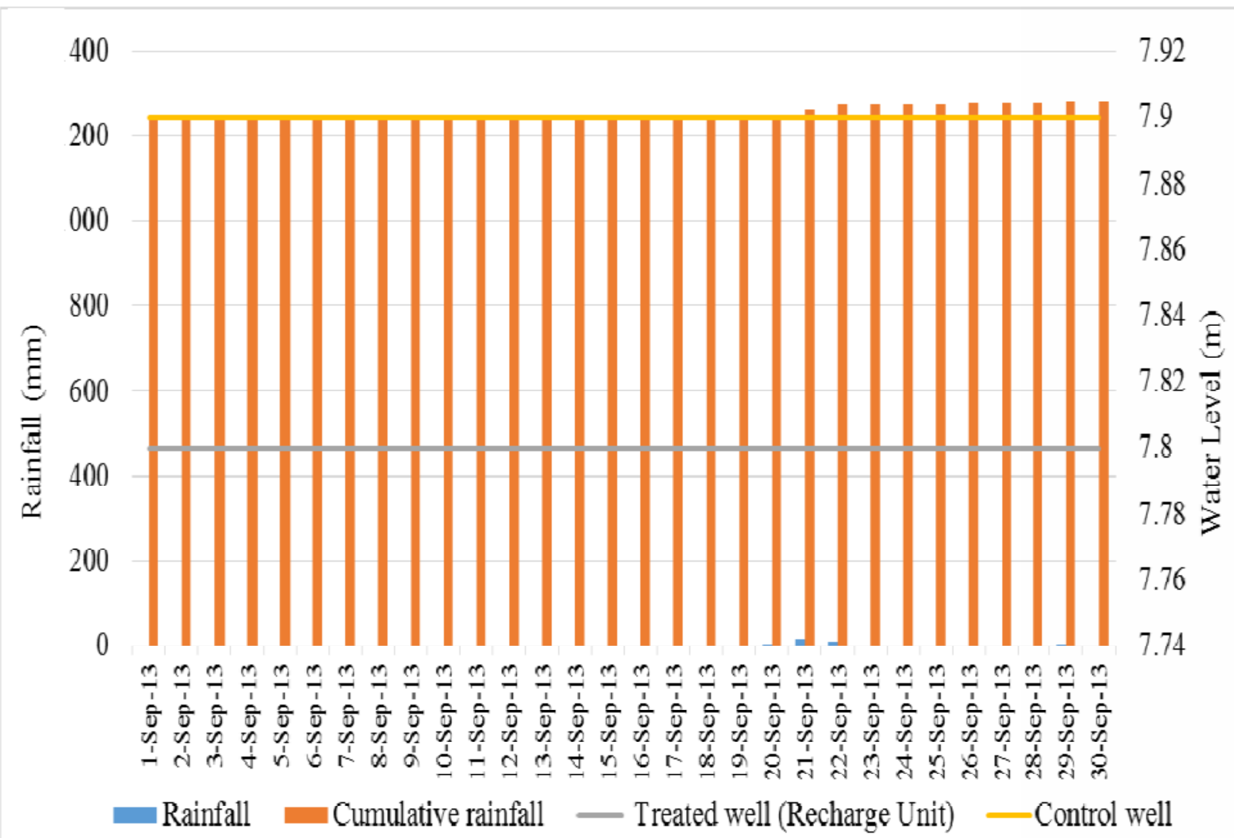

Fig. 6. Water table behavior for the month of September.

Table 4: Water level status along with rainfall for the month of September.

Rainfall (mm)	Water level in Treated well (m)	Water level in Control well (m)
0	7.8	7.9
0	7.8	7.9
0	7.8	7.9
0	7.8	7.9
0	7.8	7.9
0.2	7.8	7.9
0	7.8	7.9
0	7.8	7.9
0	7.8	7.9
0	7.8	7.9
0	7.8	7.9
0	7.8	7.9
0	7.8	7.9
0	7.8	7.9
0	7.8	7.9
0	7.8	7.9
0	7.8	7.9
0	7.8	7.9
0	7.8	7.9
7.4	7.8	7.9
15.6	7.8	7.9
11.4	7.8	7.9
0	7.8	7.9
0	7.8	7.9
0.4	7.8	7.9
0.4	7.8	7.9
0	7.8	7.9
0.8	7.8	7.9
6.4	7.8	7.9
0	7.8	7.9

Table 5: Water level status along with rainfall for the month of October.

Rainfall (mm)	Water level in Treated well (m)	Water level in Control well (m)
0	7.8	7.9
0	7.8	7.9
13	7.8	7.9
22	7.8	7.9
86.2	7.8	7.9
6.6	7.8	7.9
0	7.8	7.9
0.6	7.8	7.9
0	7.8	7.9
0	7.8	7.9
0	7.8	7.9
4.7	7.8	7.9
6.6	7.8	7.9
0	7.8	7.9
0	7.81	7.9
0	7.81	7.9
0	7.81	7.9
0	7.81	7.9
0	7.81	7.9
0	7.81	7.9
0	7.81	7.9
0	7.81	7.9
0	7.81	7.9
0	7.81	7.9
0	7.81	7.9
0	7.81	7.9
0	7.81	7.9
0	7.81	7.9
0	7.44	7.9
0	7.44	7.9
0	7.44	7.9

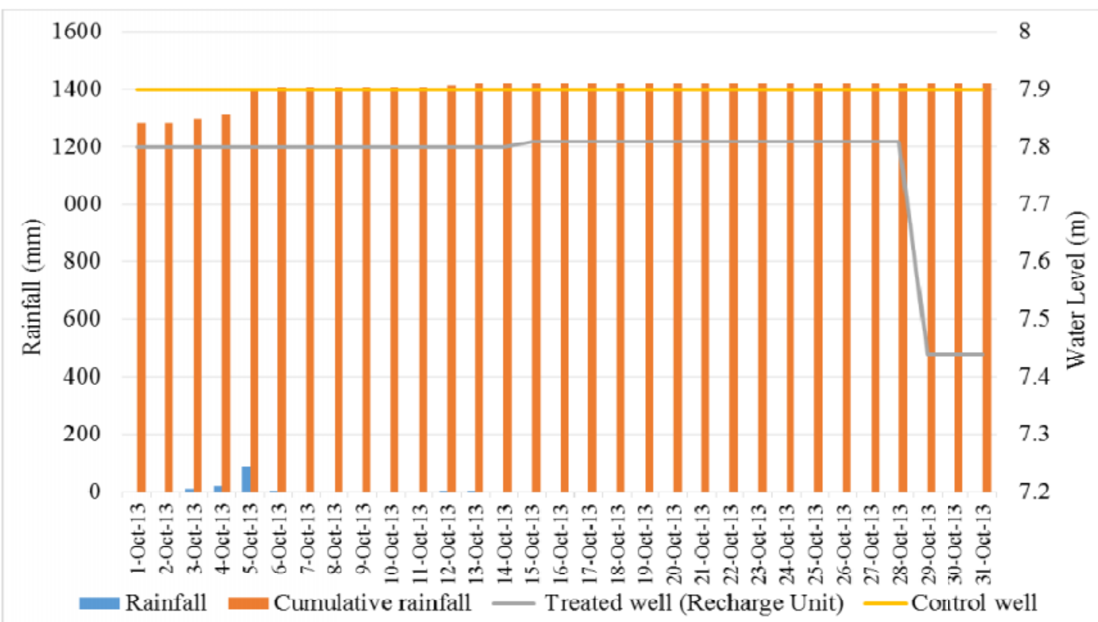

Fig. 7. Water table behavior for the month of October.

CONCLUSIONS

This study concluded that artificial groundwater recharge technique with WRU was found satisfactory and sustainable where annual rainfall is up to 1100 mm. In semi-arid areas, especially in Bundelkhand region fluctuation in water table behavior can be expressed in quantitative description by adopting water table fluctuation method. Water table fluctuation (WTF) method is a well accepted and convenient technique for estimating groundwater recharge in hard-rock regions (Sharda *et al.*, 2006; Dewandel *et al.*, 2010; Glendenning and Vervoort 2010; Garg and Wani, 2012; Singh *et al.*, 2014). Adoptive method for groundwater recharge is also most effective in such area where slope is higher and soil depth is less. Water level in the wells was increased after implementing WRU and the level which was increased recorded as 12.14 percent.

Conflict of interest. There are neither conflictions nor any body take interest.

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