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Rainwater Harvesting through Point Recharge Method for Efficient Recharge of Tube Wells for Sustainable Management of Groundwater Resources in Karnataka

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Water is a precious natural resource for sustaining life, agriculture and environment. The dependability on groundwater has reached high in all time in recent decades due to reasons such as unreliable supplies from surface water due to vagaries of monsoon, increase in demand for

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domestic, agricultural and other purposes. Karnataka is largely dependent on groundwater to meet industrial, municipal, domestic and irrigation needs. So, Rainwater harvesting (RWH) forms an important component for development and management of water resources for domestic, agricultural, municipal and industrial uses. Management of scanty rain fall by rain water harvesting, Augmentation of depleting natural resources of water (deeper ground water table) and Management of poor-quality ground water and scope for conjunctive/domestic use is need of the hour. With increase in withdrawal of ground water, ground water (GW) table is declining at a rapid pace with an urgent need to recharge GW in addition to dilute poor quality ground water. Double ring technique of Groundwater Recharge consists of filtering the water at different layers using gradation materials generally the pebbles of different size with synthetic material wrapped around the casing pipe. By harvesting rain water and recharging into point recharge soaking infiltration gallery established at Irrigation Water Management Research Centre, (IWMRC) Belavatagi Tq: Navalagund has shown encouraging results as far as water quality, discharge and water table are concerned. The results of assessment of influence of ground water recharge through rainwater harvesting on ground water yield (lps), quality (dS/m) and fluctuations (feet bgl) during the year 2020, have shown that around 3.35 lakhs liters of water could be collected from rain water harvesting during the year 2020. Also, from point recharge through 7 recharge events (rain fall events from July to October 2020), it was observed that the considerable rise in the water table from more than 100 feet below ground level to around 22 feet below ground level, drastic reduction in groundwater salinity i.e. electrical conductivity (EC) of ground water from more than 10 dS/m to an average (EC) of 1.32 dS/m and tube well yield has significantly increased from 0.4 lps to around 2.4 lps. Therefore, Artificial recharge techniques through rainwater harvesting can be a better strategic approach to combat the emerging problems of water scarcity especially over exploitation of ground water and its quality deterioration.

Keywords: Rainwater harvesting; groundwater; irrigation; water management.

1. INTRODUCTION

Water is a naturally flowing resource that is constantly recharged. However, by 2025 it is estimated that around 5 billion people, out of a total population of around 8 billion, will be living in countries experiencing water stress. Climate change has the potential to impose additional pressures in some regions. Central Groundwater Board of India defines artificial recharge as the process by which the groundwater reservoir is augmented at a rate exceeding that under natural conditions of replenishment (CGWB, 1994). Artificial recharge systems are the engineered systems where surface water is put on or in the ground for infiltration and subsequent movement to aquifers to augment groundwater resources. To overcome this problem it is essential to conserve every drop of rainwater that falls and use it for local needs throughout the year. Rain Water harvesting forms an important component for development and management of water resource for domestic, agricultural, municipal and industrial uses and there is a need for collecting and storing the rainwater during the monsoon period and to use the same for non-mansoon periods by means of water harvesting structures and artificial groundwater recharge techniques [1]. The groundwater profile of Karnataka on the other hand, being extremely fragile is subject to constant depletion. As per the report on Dynamic Groundwater Resources of Karnataka March – 2020, dynamic groundwater resources of the state of Karnataka assessed taking watershed as a unit indicated that out of the 234 assessment units, 124 watersheds are safe, 36 watersheds are semi-critical, 13 watersheds are critical and 61 watersheds are Over exploited.

This scanty water profile provides all the more impetus for the conservation of water in Karnataka and its better management. The dependability on groundwater has reached high in all time in recent decades due to reasons such as unreliable supplies from surface water due to vagaries of monsoon, increase in demand for domestic, agricultural and other purposes. This resulted into over exploitation all over the Karnataka state and in certain places it has reached critical levels like drying up of aquifers, rapid increase in water table and brackish ground water etc. warranting immediate attention from engineers and planners for formulating plans on a war footing to augment the ground water storage. Groundwater resource in Karnataka is under severe stress for years owing to increasing demand and unwise planning. About 30 per cent of the state has been over exploited and the over-draft is estimated to be about 0.22 million-hectare meters. The groundwater exploitation went unabated due to absence of any institutional control. The current practice of water management is not supported by legislative control of these adverse impacts [2].

Many districts of Karnataka state experience drought once in every 3 years. Therefore, indigenous suitable technologies for ground water recharge are to be explored and ultimately, it is needed to educate and train farmers to rejuvenate defunct wells (Tube wells/ Bore wells). In this context, IWMRC Belavatagi operating All India Co-ordinated Research Project on Irrigation Water Management has undertaken an experiment on Assessment of influence of groundwater recharge on groundwater quality, yield and water table fluctuations during the year 2020-21.

2. MATERIALS AND METHODS

A. Selection of Tube well for Recharge

IWMRC Belavatagi has a tube well (more than 450 feet with low water quality with high salinity of more than 10 dS/m). The details of tube well are given in Table 1.

B. Tube well Recharge Technique

Double ring technique for tube well recharge was carried out and recharge pit around existing tube well was constructed. The constructional procedure is described. Five pits of 1m diameter was excavated around the vicinity of tube well. out of five one is pits one is cantering the casing of bore well. Accept this pit in all the pit, 1 m diameter concrete rings were inserted. Filter holes of 5-6 mm are made on casing pipe up to 5 m leaving 0.25 mat both upper and lower side and then high quality nylon mesh wrapped tightly around the casing pipe. First bottom layer of the pit filled with big sized boulders from base up to 0.60 m. Second layer layer filled with 40 mm jelly 0.60 m. Third layer filled with 20 mm jelly of 0.60m. Fourth and fifth layer again filled with 40 mm and 20 mm jelly measuring 0.30 m each respectively. Sixth layer spread nylon mesh over which fill charcoal. Then finally seventh layer filled with sand measuring 0.30m depth and remaining space left unfilled for ponding of runoff water. Excess rain water through run-off from the adjoining fields was diverted to these concrete ring pits and tube well by passing through a silt trap and farm pond (Figs. 1 and 2). Afterwards, the sediment laden runoff water gets filtered in each layer of filtration mechanism and then percolates in to bore well. Afterwards Weekly/ monthly / seasonal variation of Ground Water Quality & fluctuation in yield and water levels was assessed after point recharge.

C. Weather conditions at IWMRC Belavatagi, during 2020

Month wise rain fall and rainy days received during the year 2020 and average of last 36 years are presented in the Table 2. The total rain fall of 876.90 mm was received during the year 2020 as compared to average rain fall of 578.29 mm. The total rain fall spread over 54 rainy days as compared to average rainy days of 40.91. The early monsoon rain fall received during March, April and May months (00.00, 89.00 and 50.40 mm, respectively). In June, 148.50 mm of rain fall was received. This helped in increasing the soil moisture and set the conditions of good run off events for ensuing rain events. In July and August the rainfall received was 90.60 and 150.20 mm, respectively and quite higher as compared to normal rains. Later during September and October recorded 147.50 mm and 196.70 mm as compared to normal rainfall of 130.75 mm and 73.96 mm, respectively. Overall, heavy rainfall (876.90 mm) was received during 2020 and floods were experienced in this part creating good conditions for rain water harvesting and artificial recharge to tube wells.

D. The Details of Ground water Recharge (GWR)/Tube well recharge unit installed at the IWMRC Belvatagi are as follows

Date of installation: 15.03.2020
Cost of GWR unit: Rs. 33,000 (Without Farm Pond and Silt trap)
Technique: Double ring technique
Size of Ground water Recharge **(**GWR) Unit: 12 x 5 x 8 feet

3. RESULTS AND DISCUSSION

The total rain fall of 876.90 mm was received during the year 2020 as compared to average annual rain fall of 578.29 mm. The total rain fall spread over 54 rainy days as compared to average rainy days of 41 days. After many rain fall events the run off generated by excess rainfall tube well was recharged by rainwater harvesting. The details of 7 recharge events from July to October 2020 for Tube well recharge are given in Table 3.

Table 1. Parameters related to tube well at the IWMRC Belvatagi

Sl. No.	Particulars	
1	Date of drill	02.11.2015
2	Date of Commissioning	01.01.2016
3	Depth of Drill	451 feet
4	Depth of casing pipe	140 feet
5	First water touch	180 feet
6	Static water level	120 feet
7	Well yield as per drill report	0.4 lps (314 GPH)
8	Pump set	5 HP with 12 stages, Submersible
9	Total cost (Bore well, motor and pump)	Rs.2,25,000

Table 2. Rain fall and number of rainy days during 2020 and average of 36 years

Months	Normal Rainfall of 36 Years (mm) 1985-2020	Rainfall (mm) 2020	No. of rainy days 2020
Jan.	1.77	0.00	0
Feb.	1.24	0.00	0
Mar.	13.21	0.00	0
Apr.	31.93	89.00	3
May	40.65	50.40	3
Jun.	87.68	148.50	5
Jul.	83.00	90.60	11
Aug.	80.93	150.20	10
Sep.	130.75	147.50	10
Oct.	73.96	196.70	11
Nov.	28.85	4.00	1
Dec.	4.49	0.00	0
Total	**578.29**	**876.90**	**54**

Table 3. The details of rainwater harvesting for tube well recharge

Recharge Event No.	Date(s)	Rainfall details, mm	Amount of Recharge in litres
1	25.06.2020, 26.06.2020	77,39	77,300
2	04.08.2020, 05.08.2020	54,25	88,000
3	02.09.2020	40	53,000
4	12.09.2020, 15.09.2020	33, 15	30,000
5	25.09.2020	32	20,500
6	09.10.2020, 12.10.2020 to 14.10.2020	136	37,750
7	19.10.2020 to 21.10.2020	45	28,350
Total			**3,34,900**

3.1 The Impact of Rain Water Harvesting on Ground Water/Tube well water

Impact of Rainwater harvesting for Tube well recharge was studied by observing weekly measurements of water table (WT) below ground level (bgl), Tube well yield in litres per second (lps) and water salinity *i.e.* electrical conductivity of tube well water in dS/m. The details of impact are as in Table 4. Very short duration pumping tests were done and static water levels were recorded.

Details of withdrawal of water: After tube well recharge, withdrawal of tube well water was done for domestic use and critical irrigation from tube well by pumping. The details of month-wise withdrawal are given in Table 5.

The results of assessment of influence of ground water recharge through rainwater harvesting on ground water yield (lps), quality (dS/m) and fluctuations (feet bgl) during the year 2020, have shown that around 3.35 lakhs liters of water could be collected from rain water harvesting during the year 2020. Also, from point recharge through 7 recharge events (rain fall events from July to October 2020), it was observed that the considerable rise in the water table from more than 100 feet below ground level to around 22 feet below ground level, drastic reduction in groundwater salinity i.e. electrical conductivity (EC) of ground water from more than 10 dS/m to an average (EC) of 1.32 dS/m and tube well yield has significantly increased from 0.4 lps to around 2.4 lps. Further, during July to December 2020, around 2.16 lakhs litres of water was withdrawn from tube well for domestic purposes of the institute. The runoff water diverted from the catchment area to recharge pit of low yielding bore well resulted in increased discharge rate and decreased water salinity. Similar results have been reported by Ramachandrappa et al. [3]. Therefore, artificial recharge techniques through rainwater harvesting can be a better strategic approach to combat the emerging problems of water scarcity and groundwater quality deterioration [4-10].

Table 4. The impact of Rain water harvesting for artificial recharge

Month(s)	**Water Table (feet bgl)**	**Well yield, (lps)**	**Water EC (dS/m)**
Before installation of Tube well Recharge unit during March 2020			
March, April, May and June 2020 before rainfall			
	100	**0.77**	**10.22**
After installation of Tube well Recharge unit with rain fall events/ recharge events			
July 2020	25	2.14	3.89
Aug. 2020	23	2.40	1.55
Sept. 2020	25	2.35	1.43
Oct. 2020	17	2.50	0.37
Monthly Average	**22**	**2.40**	**1.32**

Table 5. The monthly withdrawal of tube well water for domestic use

Month	**Withdrawal from tube well, litres**
Jul. 2020	8,148
Aug. 2020	25,377
Sept. 2020	46,475
Oct. 2020	42,408
Nov. 2020	59,274
Dec. 2020	34,680
Total	**2,16,362**

Fig. 1. A farm pond for ground water/tube well recharge at IWMRC Belavatagi (before recharging rain fall events)

Fig. 2. A farm pond for tube well recharge at IWMRC Belavatagi (After recharging Rain fall events)

4. CONCLUSIONS

1. In view of climate change, Karnataka is prone to frequent droughts and floods. The agriculture sector continues to be the mainstay of the state and its production and productivity is directly linked to availability of surface and ground water resources
2. Artificial Recharge techniques through Rainwater harvesting can be a better strategic approach to combat the emerging problems of water scarcity and groundwater quality deterioration.
3. There is a need to suggest indigenous suitable technology for ground water recharge for different hydro-geological set ups and assess the influence of ground water recharge on water quality, ground water yield after long duration pumping tests, and demonstrate to farming community for rainwater harvesting in a sustainable manner. The RWH techniques have to be encouraged and popularized [11-16].

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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