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Research Article

Impact Assessment Analysis of Artificial Recharge Scheme in a Sub-Micro Watershed, Manjeshwar Block in Lateritic Terrain of Peninsular India

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Abstract

The sub-micro watershed in 42 acres of land owned by Govinda Pai Memorial Govt. College, Manjeshwar Block, Kasaragod District in the lateritic Peninsular India has been selected for the demonstrative project on artificial recharge of ground water. In the study area ground water occurs under water table condition in laterites and the weathered zone and semi-confined conditions in the fractured crystalline aquifers. The water level in the area ranges between 6 to 25 meters below ground level (mbgl) depending on the geomorphic settings and the prevailing hydrogeological conditions. The study area is underlain thick laterite at the top followed by Archean crystalline rocks and thickness of laterite ranges from 5 to12 m. The major rock is Gneissic charnockite, with intrusions of dolerite. The Charnockite basement is highly disturbed tectonically, resulting in moderate to high yielding fracture zones at depth. Open wells tap phreatic aquifer mainly comprising laterites. They have depths of 9 to 15 m and mostly non-perennial. The average depth of bore wells in this area is 70 m, mostly tapping the fractured crystalline aquifers. The average water levels during pre- and post-monsoon periods are 11 and 7 mbgl respectively. The seasonal water level fluctuation ranges from 1 to 5 m. The ground water in the area is fresh and suitable for all uses. The various artificial recharge (AR) schemes like check dam, gabion check dam, Side protection wall, Recharging Pond with Check dam, Circular Recharging Pond, Contour trenches/bunds, Planting trees and Agrostological measures have been adopted in the area. An Impact Assessment Analysis (IAA) of Artificial Recharge Structures carried in the area by water level monitoring in observation wells on sloping lands and valleys during the period are indicated replenishment of the phreatic aquifers in the area. The construction of artificial recharge in the sub-micro watershed has substantially improved the sustainability of both dug and bore wells in the downstream side of the sub-micro watershed and improvement in vegetative cover in the area.

Keywords: Sub-micro Watershed; Aquifer; Check Dam; Gabion and Hydrograph

Introduction

The study area lies in the laterite terrains of Peninsular India. The laterites are formed by weathering under tropical and sub-tropical climatic conditions with alternate wet and dry conditions. In humid tropical regions they form extensive phreatic aquifers with high vertical variability in water storage and transmissive properties. Impact Assessment Analysis (IAA) of artificial recharge scheme at Manjeshwar, in Lateritic Terrain of Peninsular India has been studied. The feasibility of the structures in increasing ground water potential has been evaluated for different artificial recharge

structures like check dam and percolation pond with percolation wells, individually as well as in a combined manner in Nadiyapattu village of Cuddalore District, Tamil Nadu state, India has been carried out by Marykutty Abraham and Mohan [1]. Johnson., *et al*. [2]. Studies on Geochemical transformations during artificial groundwater recharge was carried out by Johnson. Saleem., *et al*. [3] done analysis of groundwater quality improvement using rainwater harvesting: a case study of Jamia Millia Islamia and many others. The present work in an educational institution in the in lateritic terrain of Peninsular India.

Study area

A sub-micro watershed in 42 acres of land owned by Govinda Pai Memorial Govt. College, Manjeshwar block in Kasaragod district, Kerala state has been identified for constructing recharge structures. As the watershed having area between 1 and 100 hectares, the watershed can be considered as sub micro watershed [4]. The location details are compiled (Figure 1). The monsoonal seasons of the area are southwest monsoon from June to September and northeast monsoon October to December. The study area is experiencing annual rainfall over 3500 mm with mean maximum and minimum temperatures between 31.68 and 20.57°C respectively. The major aquifer types in the area are alluvium, laterite and crystallines. the yield of wells in alluvium ranges from 10 to 50m^3/day. the dug wells have the depth ranges from 4 to 8 mbgl. Filter point wells with a depth of about 6 meters are constructed long the coastal areas especially along Kasaragod, Kanhangad and Padannakkad areas. The yield of wells in laterite ranges from 5 to 60 m^3/day in winter period and it returns to 2 to 20 m^3/day in summer. In weathered crystallines the yield of well ranges from 1 to 10 m^3/day in summer period. Ground water occurs under water table conditions in laterites and the weathered zone and under semi-confined conditions in the fracture zones in hard rocks. Ground water extraction for domestic and irrigation uses is mainly from the phreatic aquifers in the laterite and weathered zone through dug wells. Bore wells are slowly becoming the preferred ground water abstraction structures in the district in recent years, owing mainly to the lack of sustainable yields from the dug wells as well as land availability constraints [5].

The yield of wells in alluvium ranges from 10 to 50m^3/day. The dug wells have the depth ranges from 4 to 16 mbgl, some of the wells in laterite uplands in Kasaragod taluk have depth up to 26 m bgl. Filter point wells with a depth of about 6 meters are constructed long the coastal areas especially along Kasargod, Kanhangad and Padannakkad areas. The yield of wells in laterite ranges from 5 to 50 m^3/day in winter period and it returns to 2 to 10 m^3/day in summer. In weathered crystallines the yield of well ranges from 1 to 10 m^3/day in summer period. The Annual Extractable Ground Water Recharge of the district is 285.75 MCM and existing Gross Ground Water Extraction is of the order of 227.58 MCM. The Stage of Ground Water Extraction is 80%. Out of 6 blocks in the district, 1 has been categorized as 'Critical', 3 as 'Semi-critical' and 2 blocks as 'Safe'. The Kasaragod block is categorized as Critical and Kanhangad, Karadka and Manjeshwar blocks are categorized as Semi-critical. The in-storage ground water resources of phreatic zone (unconfined aquifer) is249.96 MCM, the semi- confined zone is 150.42 MCM and the confined zone is 195.76 MCM. The total ground water resources of the district are 881.88 MCM. The major part of the watershed is barren, with small plants and bushes.

Figure 1: Location Map of the study area.

Materials and Methods

The artificial schemes were selected on the basis of topography, geology, thickness of weathered zone, depth to water level and availability of various sources at the catchment. The SOI Toposheets, satellite imagery, field traverses resulted in choosing the sub-micro watershed in the premises of Govinda Pai Memorial Government College in the lateritic terrain for implementing the AR schemes. After the implementation of the AR schemes, IAA has been carried out in the area by using various tools.

Results and Discussions

The various processes and factors related to the artificial recharge to ground water are briefly discussed.

Planning of artificial recharge schemes

The artificial recharges are site specific and steps in planning of the project are

- Identification of the area,
- Hydrometeorology of the area,
- Hydrological studies,
- Soil infiltration studies,
- Hydrogeological studies,
- Geophysical studies, and
- Chemical quality of source water.

Monitoring and impact assessment

The monitoring of water levels and water quality is of prime importance in any scheme of artificial recharge of ground water. The periodic monitoring of water levels can demarcate the zone of benefit. The impact assessment of artificial recharge schemes can generally be enumerated with the points like conservation and harvesting of surplus monsoon, rise in water level, ground water structures in the benefited zone of artificial recharge gain sustainability and the wells provides in lean moths, change in cropping pattern, change in vegetation cover, quality of ground water- besides the direct measurable impacts. The artificial recharge schemes will generate indirect benefit in terms of decrease in soil erosion, improvement in fauna and flora influx of migratory birds etc.

Topographic setting

The study area is characterized by elevated and undulating topography comprising mainly two channels and several sub channels. These channels meet at a point from where a stream originates. The main channel, starting from the southeastern side of the College building trend along north south. A long channel also starts from southwest side of the college quarters also trend north south. The sub-micro watershed is characterized by a narrow bottle necked out let through which to whole surface water escapes to the downstream. The seasonal streams trend along north-south.

Hydrogeology

The sub-micro watershed is underlain thick laterite at the top followed by Archean crystalline rocks. The thickness of laterite ranges from 5 to12 m. The major rock is Gneissic charnockites, with intrusions of dolerite. The Charnockite basement is highly disturbed tectonically, resulting in moderate to high yielding fracture zones at depth. Open wells tap phreatic aquifer mainly comprising laterites. They have depths of 9 to 15 m and mostly non-perennial. The average depth of bore wells in this area is 70 m, mostly tapping the fractured crystalline aquifers. The average water levels during pre- and post-monsoon periods are 11 and 7mbgl respectively. The seasonal water level fluctuation ranges from 1 to 5 m.

Justification for artificial recharge

Water available in the open wells is insufficient to meet the requirements, especially in the summer months and most of the open wells in this area get dried up during this period. Bore wells are now becoming the preferred ground water abstraction structures for domestic and irrigation purposes. Due to increasing extraction of ground water for irrigation, the water levels show declining trends in parts of the area. The farmers are facing acute shortage of water for irrigation during summer. The open wells and bore wells in the college campus are not sufficient to meet the water requirements of the college. Manjeshwar block is categorized as semi critical as in March 2013 on the basis of Stage of ground water development and long-term water level trends.

Source of water availability

The present proposal envisages utilizing the rainfall available in the sub-micro watershed having catchment area of 42 acres. The average rainfall for the last 12 years is 3500 mm in Kasaragod district. The available quantity of rain water in the water shed is 3, 78,000 cu.m in a year. Considering a rain fall of 20 mm/day, the water available in the catchment area will be 33600 cu.m. A major portion of the water was supposed be recharged by the proposed structures and the surplus water would be allowed to flow from the recharge pit situating at the out let.

Recharge structures proposed

In the sub-watershed, a large quantity of rain water flows as surface run off through the channel and streams during monsoon. In order to augment the ground water recharge, suitable streams

are delineated for specific recharge structures in the area. In the upstream side the two important channels are joining at a place where a seasonal stream starts. It was proposed to construct 50 Nos. of loose boulder dams in the channels. It was also proposed to construct a sedimentation tank at a place where the two channels are joining. The rain water after sedimentation flows through the seasonal streams which again checked by constructing 6 no. of gabion check dams along the stream. A large recharge pit is also proposed at the out let of the water shed of size 20 m x 15 m x 5 m. It was also proposed to construct large number of trenches along the slope of the catchment area in order to check the surface flow and increase the ground water recharge. The details of the various structures proposed are shown in Table. Schematics of structures proposed are given in Figure 2.

Figure 2: Location of artificial recharge structures constructed in the area.

#	Type of Structure	Numbers proposed
1	Loose boulder check dams in small streams (1 m wide)	60
2	Loose boulder check dams in small streams (3 m wide)	8
3	Loose boulder check dams in small streams (5 m wide)	4
4	Gabion Check Dams (5 m wide)	6
5	Gabion Check Dams (8m wide)	3
6	Side protection wall (Retaining wall) (Middle reach)	40 Running Meter
7	Side protection wall (Retaining wall) (Lower reach)	20 - do -
8	Recharging Pond with Check dam (Middle reach)	1
9	Circular Recharging Pond (Near outlet)	1
10	Contour trenches/bunds	10 Ha.
11	Planting trees and Agrostology measures	10 Ha.

Table 1: Artificial Recharge Structures Proposed in the study area.

Impact assessment analysis (IAA) of artificial recharge structures

The IAA of the artificial schemes implemented was carried out by water level monitoring, checking the sustainability of wells and studying the improvement in vegetative cover in the sub-micro watershed

Water level monitoring in observation wells (OBWs)

There were 9 OBWs established in the downstream side of the project area (Figure 3) and depth to the water table (DTW) monitored at regular intervals between April 2010 and May 2012 and are compiled (Table). The hydrographs of OBWs located on sloping lands and valleys during the period are prepared (Figure 4 A and B). The monitoring the OBWs indicated replenishment of the phreatic aquifers in the area. Wells which were regularly becoming dry during peak summer have ceased to be so and the water columns available during summer months have increased significantly.

Figure 3: Locations of observation wells established in the study area.

Sustainability of wells

Enquiries with the local residents one year after implementation of the scheme on the improvement in the performance of ground water abstraction structures have revealed that the construction of artificial recharge in the sub-micro watershed has substantially improved the sustainability of both dug wells and bore wells in the downstream side of the sub-micro watershed. Improvements, both in terms of yields of bore wells and pumping hours have been reported, prompting the farmers in the area to either increase the command area of wells or to go for more water-intensive crops such as plantain.

Improvement in vegetative cover in the sub-micro watershed

Visits to the scheme area subsequent to the completion of the scheme have revealed a gradual increase in the vegetative cover in the sub-micro watershed as a whole, partly due to growth of natural vegetation under better soil moisture availability and partly due to growth of sapling planted as part of agrostology measures taken up during the project.

Well ID	Owner	Well Type	Depth (mbgl)	Dia., m	Depth to Water Table, mbgl						Landform unit
					03/2010	05/2010	01/2011	08/2011	12/2011	05/2012	
W 1	Ms. Susheela	D	14.37	2.5	14.37	14.37	10.09	9.00	10.30	13.87	Slope
W 2	Balakrishna Shetty	D	4.30	3	4.3	4.3	3.54	1.15	3.30	4.10	Valley
W 3	Sasidhara Shetty	D	9.30	3	8.80	8.40	5.20	3.40	5.24	7.34	Gentle Slope
W 4	Balakrishna Shetty	D	6.65	2.75	5.70	5.95	3.47	1.60	3.33	3.13	Valley
W 5	Narasimha Shetty	D	7.73	2.5	6.53	6.84	4.13	2.10	4.12	6.51	Gentle Slope
W 6	Shivananda	D	7.20	2.75	5.71	5.93	2.50	0.50	2.55	5.68	Valley
W 7	Balakrishna Shetty	D	4.32	4 x 5	3.19	3.32	0.80	0.20	0.60	3.01	Valley
W 8	Andhunji	D	3.92	2.75	3.18	3.26	0.96	0.10	0.88	3.11	Valley
W 9	Nagaraja Naik	D	6.90	10 x 5	5.80	5.98	3.20	1.30	3.25	5.76	Gentle Slope

Table 2: Water Level Data of Observation Wells in the study area.
D: Dug well.

Figure 4A: Hydrographs of Observation Wells in the Downstream Area (valley) of AR Structures.

Figure 4B: Hydrographs of Observation Wells (on slopes) downstream of artificial recharge Structures constructed in the study area.

View of the channel after monsoons in 2010.

View of the Circular Recharge Pit filled with water.

Vegetative cover over the sub-micro watershed before the implementation of artificial recharge and agrostology measures.

A view of the sub-micro watershed after implementation of artificial recharge and agrostology measures.

Figure 5: A few Field photos in the study area before and after the implementation of the project.

Conclusion

The implementation of artificial recharge scheme in the campus of Govinda Pai Memorial Government College, Manjeshwar, Kasaragod district, Kerala has been found to be effective in conserving the monsoon runoff at sub-micro watershed level and also in replenishing the ground water resources in the area. The scheme has also demonstrated the types of recharge structure feasible for undulating terrains of lateritic terrain of Peninsular India for cost-effective recharge augmentation structures.

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Volume 4 Issue 1 January 2020